U. S. Fish and Wildlife Service
Region 2

CONTAMINANTS INVESTIGATION OF WESTERN PORTION OF CADDO LAKE NATIONAL WILDLIFE REFUGE, TEXAS 2002

Project ID No. 94420-02-Y037

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ABSTRACT

In April and May, 2002, a contaminants investigation was conducted at Caddo Lake National Wildlife Refuge, an overlay refuge, by the United States Fish and Wildlife Service (USFWS). The purpose of this investigation was to determine contaminant levels in soils and/or sediments in the western portion [approximately 2,000 acres (810 hectares)] of the Refuge to ascertain the suitability of this area for transfer of primary jurisdiction from the United States Army (U.S. Army) to the USFWS. Samples were collected from 43 sites. The contaminants sampled for included metals, semi-volatile organic compounds, organochlorine pesticides, total polychlorinated biphenyls (PCBs), dioxin/furans, and perchlorate.

Metals were detected throughout the 43 sites sampled. Five of these metals were detected at high enough concentrations to warrant further investigation: lead was detected at elevated levels at four sites (Sites 19, 20, 25, and 29); manganese was measured at elevated concentrations at 16 sites (Sites 1, 2, 4, 5, 6, 7, 9, 11, 13, 15, 17, 18, 19, 21, 26, and 29); mercury was detected at elevated levels at four sites (Sites 25, 26, 27, and 29); vanadium was measured at elevated concentrations at 10 sites (Sites 6, 13,19, 25, 27, 29, 39, 41, 42, and 43); and zinc was detected at elevated levels at three sites (Sites 19, 29, and 39). Only two semi-volatile compounds, 1-naphthylamine and 2-nitroaniline, were measured above the analytical detection limits. These compounds were detected at only one site (Site 14) and at levels where adverse affects to ecological resources would not be expected to occur. Residual organochlorine pesticides were detected throughout the western portion of the Refuge. Of these compounds, elevated total-DDT levels were measured at eight sites (Sites 4, 14, 15, 19, 20, 25, 29, and 43) at high enough concentrations that further investigation into the affects to ecological resources is warranted. Total-PCBs were detected above the analytical detection limits at every site sampled. Dioxin/furans were detected at levels that do not appear to represent a concern for wildlife resources. Perchlorate was detected above the analytical detection limit at only one site (Site 1). Considering the sparsity of toxicological criteria currently available for perchlorate, the detected concentration at this site warrants further investigation.

The overall results indicated that contaminant levels were low enough at Sites 22, 23, 24, 28, and 30 through 40, that the USFWS could assume primary jurisdiction of these sites. However, further investigation is warranted prior to the USFWS assuming responsibility for Sites 2 through 13, 15 through 18, and 21 because of elevated levels of metals. In addition, due to the perchlorate level measured at Site 1 and the detection of multiple bio-accumulative contaminants at Sites 14 (total-chlordane, total-DDT, endosulfan, endrin, heptachlor epoxide, βBHC, and total-PCBs),19 (lead, zinc, total-chlordane, total- DDT, dieldrin, endosulfan, endrin, heptachlor, heptachlor epoxide, HCB, αBHC, γBHC, pentachloroanisole, and total-PCBs), 20 (lead, total-chlordane, total-DDT,

endosulfan, endrin, mirex, pentachloroanisole, and total-PCBs), 25 (lead, mercury, aldrin, total-chlordane, total-DDT, dieldrin, endosulfan, and total-PCBs), 26 (mercury and total-PCBs), 27 (mercury), 29 (lead, mercury, zinc, total-chlordane, total-DDT, endosulfan, and total-PCBs), and 43 (total-DDT and total-PCBs), further investigation and possibly remedial efforts are required prior to transfer of these areas from the U.S. Army to the USFWS.

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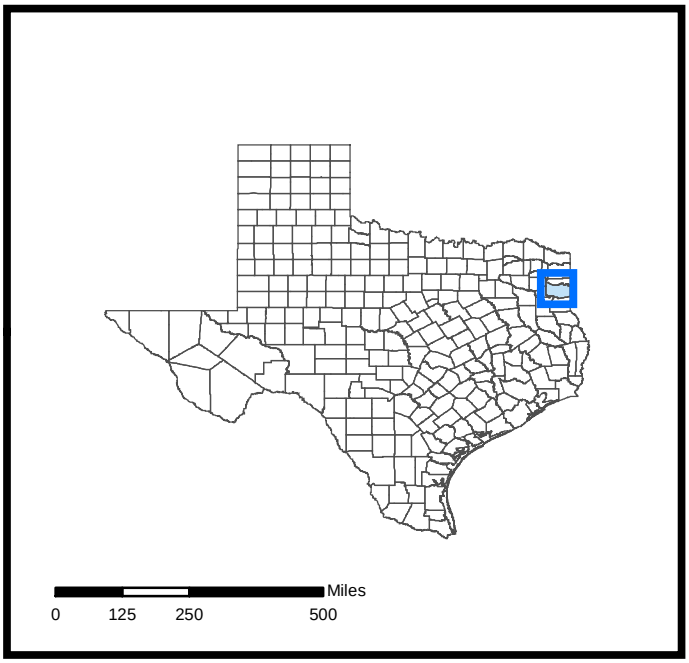
INTRODUCTION

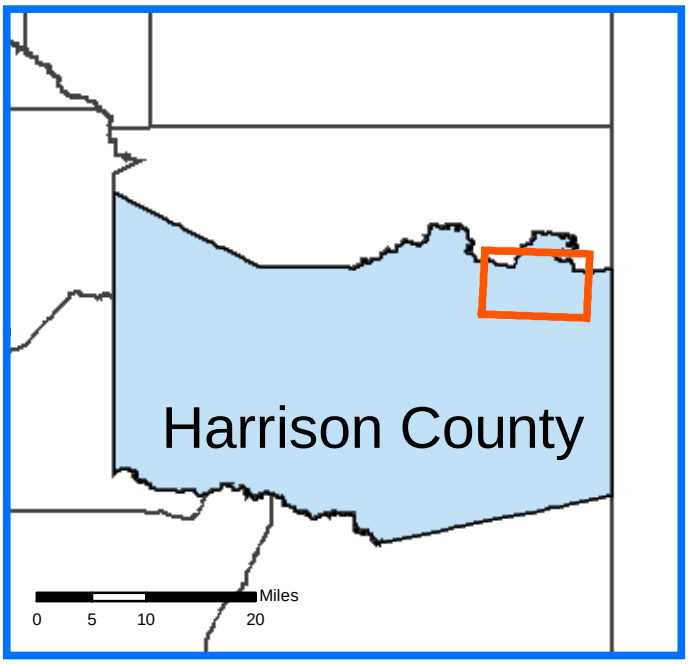
In April and May, 2002, a contaminants investigation was conducted at Caddo Lake National Wildlife Refuge by the United States Fish and Wildlife Service (USFWS). The purpose of this investigation was to determine contaminant (metals, semi-volatile organic compounds, organochlorine pesticides, total polychlorinated biphenyls, dioxin/furans, and perchlorate) levels in soils and/or sediments in the western portion [approximately 2,000 acres (810 hectares)] of the Refuge. Data resulting from this investigation would be used by the USFWS to determine the suitability of transfer of administrative control of this portion of the Refuge from the United States Army to the USFWS.

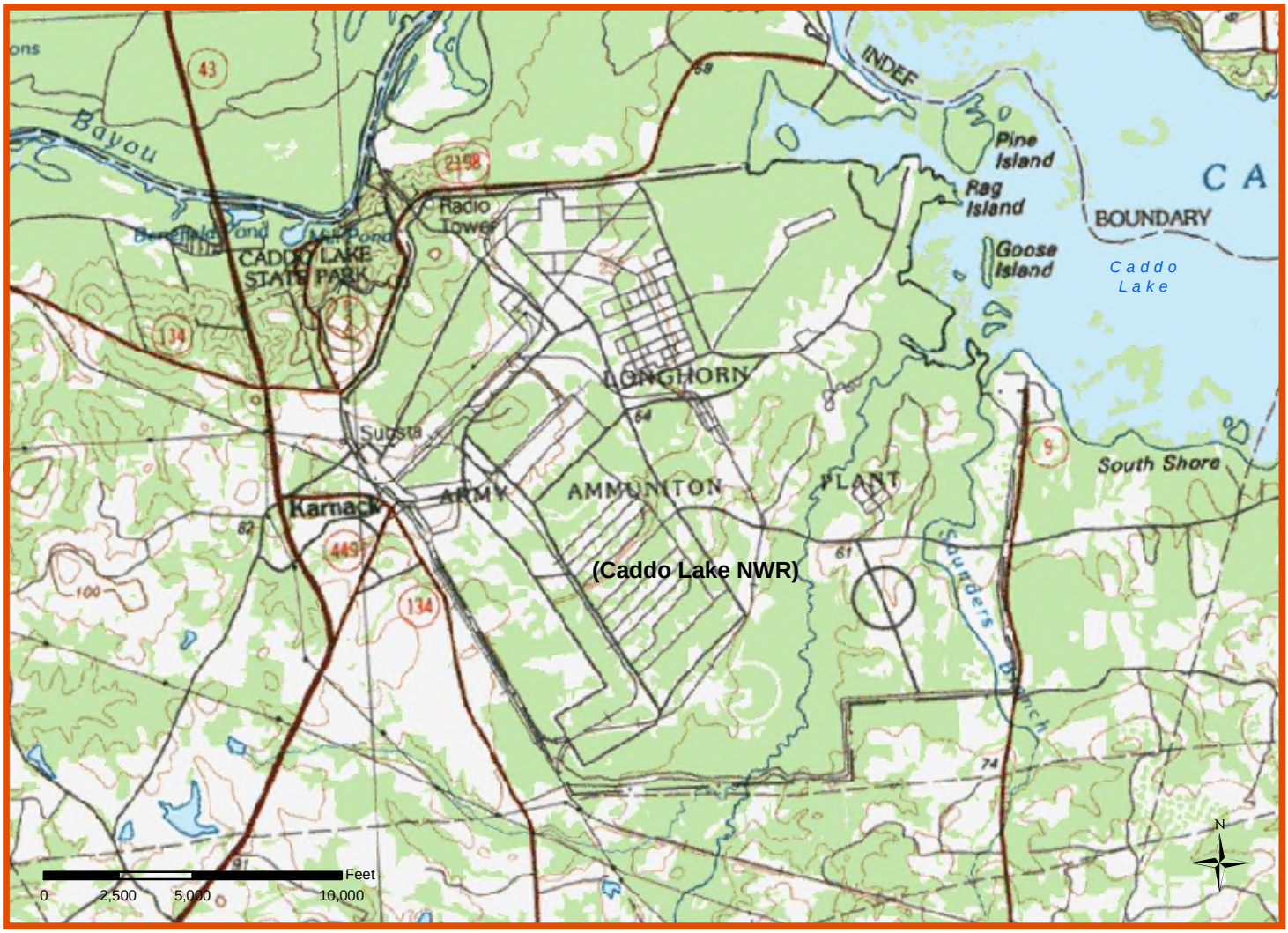
STUDY AREA & BACKGROUND

Caddo Lake National Wildlife Refuge is an overlay refuge located on the site of a former military munitions production facility in Harrison County, Texas, southwest of Caddo Lake (Figure 1). The entire site consists of 8, 493 acres (3,437 hectares)of mixed upland pine and bottomland hardwood forests interlaced with remnant structures from the munitions plant. The area is drained by four principal lotic systems, Goose Prairie Bayou, Central Creek, Harrison Bayou, and Saunders Branch, all flowing into Caddo Lake. The former production facility was known as Longhorn Army Ammunition Plant (LHAAP). This plant was established by the United States Department of Defense (USDOD) under the jurisdiction of the U.S. Army Armament, Munitions, and Chemical Command (AMCCOM) in 1941 to produce trinitrotoluene (TNT) flake through the contract operator Monsanto Chemical Company (TSHA, 2002). The plant produced over four hundred million pounds (greater than 180 million kilograms) of TNT between 1942 and 1945 (TSHA, 2002). In late 1945, TNT production ceased and Monsanto suspended all operations at the site, while the facility was placed on standby status by the USDOD (TSHA, 2002). The plant remained inactive until 1952, when operations were re-initiated under the contract operator, Universal Match Corporation to produce pyrotechnic and illuminating ammunition such as photoflash bombs, simulators, hand signals, and 40 millimeter tracers (GS, 2002; TSHA, 2002). By 1956, Morton-Thiokol Incorporated (formerly known as the Thiokol Corporation) had assumed contract operation responsibilities at the facility (GS, 2002; TSHA, 2002). From 1956 through 1965, the primary mission of the plant was the production of solid propellant rocket motors and fuels for the Nike-Hercules, Falcon, Lacrosse, Honest John, and Sergeant missile programs (GS, 2002). In 1965, the production of pyrotechnic and illuminating ammunition was re-initiated at the plant by Thiokol. The plant continued to produce munitions all during the 1960s and 1970s. At its peak, the facility employed over 2,200 people (Tolbert, personal communication, 2002).

Figure 1: Caddo Lake National Wildlife Refuge Study Area Map





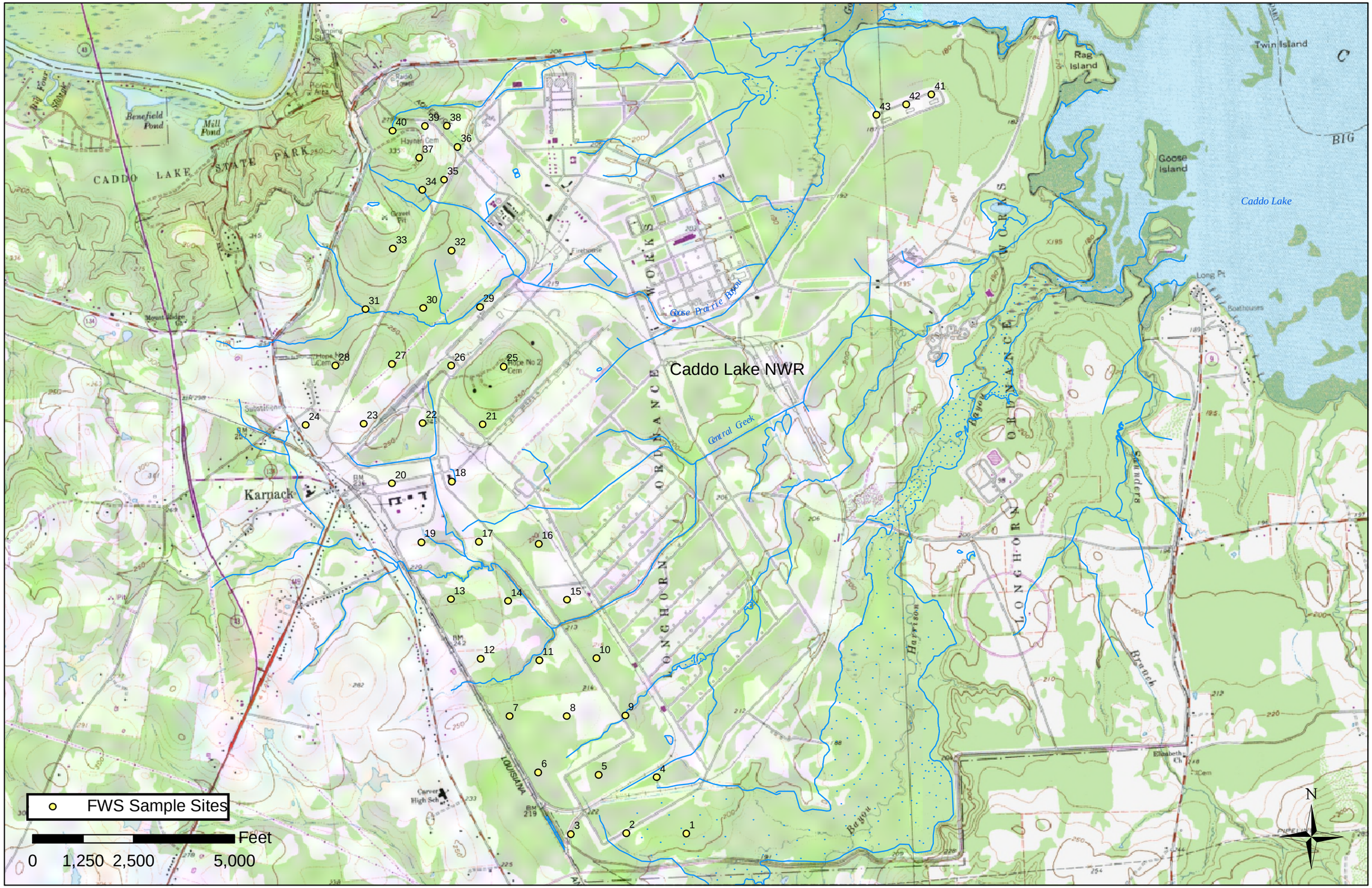


In 1987, LHAAP was selected as one of the sites for the static firing and elimination of Pershing IA and II rocket motors in order to comply with the terms of the Intermediate Nuclear Force Treaty between the U.S. and the Soviet Union (GS, 2002). This project was completed by 1991 (TSHA, 2002). In 1990, the facility was placed by the U.S. Environmental Protection Agency (USEPA) on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priority List (NPL). This listing as a Superfund site was due to groundwater, surface water, sediments, and soil contamination (ATSDR, 2002). Contaminants associated with the listing included metals, explosives, semi-volatile organic compounds, and volatile organic compounds (ATSDR, 2002). Activities to remediate this contamination were initiated in 1990 and are expected to be completed no earlier than 2030. Thiokol continued operations at the plant, primarily the production of the plastic explosive CL-20, until 1997 (ATSDR, 2002). By 1998, Thiokol had ceased operations at the site and AMCCOM had classified the plant as excess property. In 1999, negotiations were initiated between AMCCOM and USFWS over the possible absorption of the site into the National Wildlife Refuge System. In October, 2000, LHAAP became Caddo Lake National Wildlife Refuge, an overlay refuge, with the U.S. Army maintaining administrative control of the property until primary jurisdiction for the site is deemed suitable for transfer to the USFWS.

MATERIALS & METHODS

Surficial grab soil/sediment samples were collected at a depth of 0 to 6 inches [0 to 15 centimeters (cm)] from 43 sites within the western portion of Caddo Lake National Wildlife Refuge (Figure 2) by USFWS personnel in April and May, 2002. The overall area sampled covered approximately 2,000 acres (810 hectares). The individual sampling sites were selected through a computer generated stratified random matrix grid. The distance between sampling points at Sites 1 through 33 was approximately 443 meters (1,452 feet), while the distance between sampling points at Sites 34 through 40 and 41 through 43 was less than 100 meters (328 feet). Each sample was collected in a pre-cleaned glass container using a disposable plastic scoop and placed on ice in a cooler. These samples were then transported to the USFWS Arlington, Texas Ecological Services Field Office (ESFO) and remained refrigerated at 4°Celsius (°C) until submitted through the Patuxent Analytical Control Facility (PACF) to contract laboratories for chemical analyses. Samples from each site were analyzed for moisture, sand, silt, and clay content (as percentages); metals (aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, vanadium, and zinc) in milligrams/kilogram (mg/kg) dry weight; semi-volatile organic compounds [1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1-chloronaphthalene, 1-naphthylamine, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2,4-dinitrotoluene, 2,6-dichlorophenol, 2,6-dinitrotoluene, 2-chloronaphthalene, 2-chlorophenol, 2-methylphenol, 2-naphthylamine, 2-nitroaniline, 2-nitrophenol, 2-picoline, 2-methylnaphthalene, 3,3'-dichlorobenzidine, 3-methylcholanthrene, 3-nitroaniline, 4,6-dinitro-2-methylphenol, 4-aminobiphenyl, 4-bromophenyl-phenylether, 4-chloro-3-methylphenol,

Figure 2: USFWS Sample Sites at Caddo Lake NWR, 2002



4-chloroaniline, 4-chlorophenyl-phenylether, 4-methylphenol, 4-nitrophenol, 7,12-dimethylbenz(a)anthracene, acentophenone, aniline, benzidine, benzo(a)anthracene, benzoic acid, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate, bis(2chloroisopropy)ether, butylbenzylphthalate, carbazole, di-n-butylphthalate, di-n-octylphthalate, dibenz(a,h)anthracene, dibenz(a,j)acridine, dibenzofuran, diethyl phthalate, dimethylphthalate, diphenylamine, ethyl methanesulfonate, hexachlorobutadiene, hexachlorocyclopentadiene, hexachloroethane, isophorone, methyl methanesulfonate, n-nitroso-di-n-propylamine, n-nitrosopiperidine, nitrobenzene, pentachlorobenzene, pentachloronitrobenzene, pentachlorophenol, phenacetin, phenol, pronamide, a,a-dimethylphenylamine, acenaphthalene, acenaphthene, anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, n-nitrosodiphenylamine, naphthalene, p-dimethylaminoazobenzene, phenanthrene, and pyrene] in mg/kg dry weight; organochlorine pesticides [1,2,3,4-terachlorobenzene, 1,2,4,5-tetrachlorobenzene, aldrin, hexachlorobenzene (HCB), heptachlor, alpha hexachlorocyclohexane (αBHC), alpha (α) chlordane, beta hexachlorocyclohexane (βBHC), cis-nonachlor, delta hexachlorocyclohexane (δBHC), dieldrin, endosulfan II, endrin, gamma hexachlorocyclohexane (γBHC), gamma (γ) chlordane, heptachlor epoxide, mirex, o,p'-dichloro-diphenyl-dichloroethane (o,p'-DDD), o,p'-dichloro-diphenyl-dichloroethylene (o,p'-DDE), o,p'-dichloro-diphenyl-trichloroethane (o,p'-DDT), oxychlordane, p,p'-dichloro-diphenyl-dichloroethane (p,p'-DDD), p,p'-dichloro-diphenyl-dichloroethylene (p,p'-DDE), p,p'-dichloro-diphenyl-trichloroethane (p,p'-DDT), pentachloro-anisole, toxaphene, and trans-nonachlor] in mg/kg dry weight; and total polychlorobiphenyls (PCBs) in mg/kg dry weight (for analytical methods see Appendix A). At Sites 5, 10, 22, 31, and 42, additional soil/sediment samples were collected and handled in the same manner. These additional samples were submitted through PACF to be analyzed for dioxins/furans [2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), 1,2,3,7,8-pentachlorodibenzo-p-dioxin (PeCDD), 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin (1,2,3,4,7,8-HxCDD), 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin (1,2,3,6,7,8-HxCDD), 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin (1,2,3,7,8,9-HxCDD), 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD), 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin (OCDD), 2,3,7,8-tetrachlorodibenzofuran (TCDF), 1,2,3,7,8-pentachlorodibenzofuran (1,2,3,7,8-PeCDF), 2,3,4,7,8-pentachlorodibenzofuran (2,3,4,7,8-PeCDF), 1,2,3,4,7,8-hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF), 1,2,3,6,7,8-hexachlorodibenzofuran (1,2,3,6,7,8-HxCDF), 1,2,3,7,8,9-hexachlorodibenzofuran (1,2,3,7,8,9-HxCDF), 2,3,4,6,7,8-hexachlorodibenzofuran (2,3,4,6,7,8-HxCDF), 1,2,3,4,6,7,8-heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF), 1,2,3,4,7,8,9-heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF), and 1,2,3,4,6,7,8,9-octachlorodibenzofuran (OCDF)] in mg/kg dry weight (for analytical methods see Appendix A). Additional soil/sediment samples were also collected in the same manner from all 43 sites and submitted to the Institute of Environmental and Human Health at Texas Tech University to be analyzed for perchlorate content in micrograms/kilogram (μg/kg) dry weight (for analytical methods see Appendix A).

Following the methodology recommended by the USEPA (1995a), field duplicate soil/sediment samples were collected at Sites 5, 10, 22, 31, and 42 and handled in the same manner as the other samples collected from these sites. These duplicate samples were also submitted through PACF and Texas Tech University to be analyzed for moisture, sand, silt, and clay content, metals, semi-volatile organic compounds, organochlorine pesticides, total-PCBs, and perchlorate, respectively. The

purpose of these duplicates was to check the laboratory analytical procedures as well as to assess the quality of field sampling techniques. In addition to the sampling, all observed anomalies encountered in the field (i.e., drums, solid waste, foundations, etc.) were documented and their coordinates were entered into a geographical information systems (GIS) database.

RESULTS & DISCUSSION

The results of the analyses are presented in Tables 1-5 in Appendix B. Field duplicate analytical results are presented in Appendix C. Where applicable, analytical results were compared with soil benchmarks proposed by Efroymson *et al.* (1997), the USEPA, and the Texas Natural Resource Conservation Commission (TNRCC) (2001), and sediment screening criteria recommended by the Ontario Ministry of the Environment (OME) (Persaud *et al.*, 1993), Long *et al.* (1995), MacDonald *et al.* (2000), as well as with data from comparative studies to determine the extent and possible effects of contamination in soils/sediments collected from CLNWR Benchmarks and/or screening criteria are values derived from toxicity data resulting from multiple studies. Soil benchmarks are typically based on the degree of toxicity of a given contaminant to plants, earthworms, heterotrophic microbes, and other invertebrates (Efroymson *et al.*, 1997). In sediments, the OME considers the lowest effects level (LEL) indicative of a level of contamination that is non-toxic to the majority of benthic organisms, whereas the severe effect level (SEL) is indicative of contaminated sediments that would be detrimental to a majority of benthic organisms (Persaud *et al.*, 1993). In comparison, according to Long *et al.* (1995), the effects range-low (ER-L) of a detected chemical represents the lower 10^{th} percentile of toxicological effects data for that specific chemical, whereas the effects range-median (ER-M) represents the toxicological effects data for the chemical at the 50^{th} percentile. Concentrations detected below the ER-L represent a value where minimal effects would be expected, whereas concentrations detected at or above the ER-L but below the ER-M, represent a possible effects range (Long *et al.*, 1995). Concentrations detected at or above the ER-M represent a probable effects range where adverse toxicological effects would frequently occur (Long *et al.*, 1995). In a consensus based approach towards evaluating screening criteria in sediments, Macdonald *et al.* (2000), state that the threshold effect concentration (TEC) for a contaminant in sediments is the concentration below which adverse effects are not expected, whereas the probable effect concentration (PEC) is the level above which adverse effects would likely occur. As with the OME LEL and SEL values, ER-L, ER-M, TEC, and PEC values are non-regulatory sediment screening guidelines developed to assist in assessing the degree of contamination in a given area.

The measured moisture content in soils/sediments collected from the 43 sites at CLNWR ranged from 2.7% at Site 2 to 35.6% at Site 43 ($\bar{x}$ = 16.1%) (Appendix B, Table 1). The majority of the sites were dominated by sands and/or silts (Appendix B, Table 1). The samples collected at Sites 25, 27, and 43 were the only soils/sediments that were predominantly composed of clays. As would be expected, various metals were detected throughout the sites sampled (Appendix B, Table 2). Only two semi-volatile organic compounds (1-napthylamine and 2-nitroaniline) were detected above the analytical detection limits in any of the samples collected from the 43 sites (Appendix B, Table 3). Of the 27 organochlorine pesticides analyzed for in the soil/sediment samples, only two

compounds, δBHC and toxaphene, were not detected above the analytical detection limits in any of the samples collected (Appendix B, Table 4).

Field observations are presented in Appendix D. What appeared to be the remnants of a former home site were noted at Observation Point 1 (Appendix D). However, the majority of anomalies encountered at CLNWR appeared to be associated with timber harvesting operations previously conducted at the site. Empty plastic jugs found during the sampling appeared to have previously contained chain saw oil. With the exception of the observations made in the old signal test area (Observation Point 19), the vast majority of material discovered during the sampling appeared to be either recyclable material or non-hazardous municipal solid waste. It is unknown whether the material observed in the old signal test area (drums, primers, etc.) was hazardous or not, but corresponding areas of stressed vegetation indicate that further investigations are warranted. Observed physical hazards (i.e., open manhole and open pits) were also characterized and their locations documented for future corrective measures.

Metals

[Aluminum (Al)] Approximately 8.1% of the Earth's crust is composed of aluminum (Miller and Gardiner, 1998). Background surface soil concentrations in the western U.S. range up to 74,000 mg Al/kg (Shacklette and Boerngen, 1984). According to the Texas Natural Resource Conservation Commission (TNRCC) (2001), a soil-aluminum concentration of 30,000 mg Al/kg is considered background in the State of Texas. Efroymson *et al.* (1997), proposed 600 mg Al/kg dry weight as a screening benchmark value for aluminum toxicity to soil microorganisms. According to the National Oceanic and Atmospheric Administration (NOAA), the threshold effects level (TEL) for aluminum toxicity in freshwater sediments is 25,500 mg Al/kg dry weight (Buchman, 1999). Bio-availability of aluminum in an aqueous environment is driven by pH (Sparling and Lowe, 1996). Aluminum is relatively innocuous when the pH ranges from 5.5 to 7.5 but becomes soluble and biologically available when the pH is less than 5.5 (Sparling and Lowe, 1996). For many species of fish exposed to elevated levels of aluminum, toxic effects appear to correlate with decreasing pH, resulting in adverse effects that shift from asphyxiation to impaired ion regulation (Sparling and Lowe, 1996). In birds, elevated levels of aluminum in the diet can result in adverse effects in calcium and phosphorus metabolism (Sparling and Lowe, 1996). In a study conducted in the Arkansas River-Red River Ecosystem by the USFWS in 1993, whole body largemouth bass collected from Caddo Lake in Harrison County, Texas contained a $\bar{x}$ = 1.3 mg Al/kg wet weight while whole body bluegill from the same lake contained a $\bar{x}$ = 10.4 mg Al/kg wet weight (Giggleman *et al*., 1998). The National Research Council (NRC) (1980), recommends a whole body aluminum concentration of 200 mg Al/kg wet weight as the predator protection limit for piscivorus feeders. In humans, the daily average intake of aluminum is estimated to be 20 mg Al/day (Goyer, 1991). Typically, the human body maintains a balance between aluminum exposure and content within body tissues so that very little aluminum is absorbed; however, with intakes greater than 1000 mg Al/day, retention within the tissues (primarily bone and lung) usually occurs (Goyer, 1991). In turn, excess aluminum can affect absorption of other necessary elements in the gastrointestinal tract and eventually impair intestinal function (Goyer, 1991). Aluminum levels were detected above the analytical detection limits in all soil/sediment samples collected from the 43 sites at CLNWR

(Appendix B, Table 2). These concentrations ranged from 889 mg Al/kg dry weight at Site 35 to 18,160 mg Al/kg dry weight at Site 27 (Appendix B, Table 2). All of these concentrations exceeded the soil benchmark value proposed by Efroymson *et al.* (1997), but none of the measured levels exceeded the soil background values suggested by Shacklette and Boerngen (1984) and the TNRCC (2001), nor the sediment criterion proposed by NOAA (Buchman, 1999).

[Arsenic (As)] According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background elemental arsenic concentrations in surface soils in the western U.S. is 7 mg As/kg, while the TNRCC (2001), considers a soil-arsenic concentration of 5.9 mg As/kg as background in the State of Texas. Pennington (1991) reported soil-arsenic concentrations ranging up to 13.36 mg As/kg in the Texas Panhandle. Efroymson *et al.* (1997), proposed an earthworm soils toxicity screening benchmark value of 60 mg As/kg dry weight, while the U.S. Environmental Protection Agency (USEPA) (2000a) considers a soil-arsenic concentration of 37 mg As/kg dry weight as a benchmark value for terrestrial plants. In aquatic environments, elemental arsenic is insoluble in water, but many arsenic species are highly soluble in freshwater (Schneider, 1971). Common arsenic species include arsenate, arsenite, methanearsonic acid, and dimethyl arsenic acid (USEPA, 1980). In aerobic waters, reduced forms of arsenic tend to be oxidized into arsenates (USEPA, 1980). In turn, the adsorption of arsenate by metal oxides and the formation of arsenic sulfide appears to remove arsenic from the water column, binding it to the sediments, and preventing high concentrations of arsenic being present in solution (USEPA, 1980). The estimated residence time for arsenic in lentic systems is 45 years (Eisler, 1988b). The OME suggest a sediment LEL of 6 mg As/kg dry weight and a SEL of 33 mg As/kg dry weight (Persaud *et al.*, 1993), while Long *et al.* (1995), consider 8.2 mg As/kg dry weight as the ER-L for arsenic in sediments. MacDonald *et al.* (2000), recommend a sediment TEC of 9.79 mg As/kg dry weight and a PEC of 33 mg As/kg dry weight. Toxic effects of arsenic to aquatic life are significantly dependent on numerous biological and abiotic factors, including water temperature, pH, organic content, phosphate concentrations, suspended solids, and arsenic speciation (Eisler, 1988a). Birds and freshwater biota usually contain arsenic concentrations less than 1.0 mg As/kg wet weight (USDOI, 1998). According to Schmitt and Brumbaugh (1990), the national 85th percentile for arsenic in whole body fish in the United States (U.S.) is 0.27 mg As/kg wet weight. Arsenic tissue residues of 1.35 mg As/kg wet weight in juvenile bluegills and 5.0 mg As/kg wet weight in adult bluegills are considered elevated and potentially hazardous (Eisler, 1988a). Eisler (1988 a) recommends a predator protection limit of 30 mg As/kg wet weight for protection of avian species and other piscivorus wildlife. In humans and other mammalian species, arsenic can be carcinogenic and teratogenic (NOAA, 1990; USDOI, 1998). The ingestion of large doses of arsenic (70 to180 mg) by humans can be acutely fatal, while chronic exposure can lead to neurotoxicity of both the peripheral and central nervous systems (Goyer, 1991). Arsenic levels of 0.05 mg/L in the blood and greater than 0.1 mg/L in urine are indicative of excessive exposure (Goyer, 1991). Normal daily intake by humans of arsenic as residue in food is estimated at 0.012 to 0.025 mg As/day (Law, 1996). In Canada, the action level for initiating human-fish consumption advisories is triggered by a fillet-arsenic concentration of greater than or equal to 3.5 mg As/kg wet weight (USEPA, 1989), whereas in the U.S., the recommended screening criterion protective of human health for fish consumption is a tissue concentration of 3 mg As/kg wet weight (USEPA, 1995b). Arsenic concentrations were detected above the analytical detection limits in all soil/sediment samples collected from the 43 sites at

CLNWR (Appendix B, Table 2). These concentrations ranged from 0.55 mg As/kg dry weight at Site 35 to 8.4 mg As/kg dry weight at Site 20 (Appendix B, Table 2). All of the measured arsenic levels were below screening criteria with the exception of the concentrations detected at Sites 19 (7.38 mg As/kg dry weight), 20, and 42 (6.69 mg As/kg dry weight). The arsenic levels at these three sites exceeded the Texas soil background criterion (TNRCC, 2001) and the OME sediment LEL value (Persaud *et al.*, 1993). In addition, the arsenic concentrations a Sites 19 and 20 exceeded the soil background value reported by Shacklette and Boerngen (1984), while the arsenic level at Site 20 also exceeded the sediment ER-L criterion suggested by Long *et al.* (1995). However, none of the measured arsenic concentrations at these three sites exceeded the sediment TEC value recommended by MacDonald *et al.* (2000) nor approached the ecological benchmark criteria for soils suggested by Efroymson *et al.* (1997) and the USEPA (2000a).

[Barium (Ba)] Barium compounds are used in a variety of industrial applications. In nature, barium chiefly occurs as the relatively insoluble salts, barite and witherite (USEPA, 1986). Shacklette and Boerngen (1984) reported an estimated arithmetic mean of 670 mg Ba/kg as background for soils in the western U.S. while a soils concentration of 300 mg Ba/kg dry weight is considered background in the State of Texas (TNRCC, 2001). According to Efroymson *et al.* (1997), a proposed screening benchmark value for barium toxicity to soil microorganisms is 3000 mg Ba/kg dry weight, while the Texas Natural Resource Conservation Commission (TNRCC) (2001) considers a soil-barium concentration of 500 mg Ba/kg dry weight as a benchmark value for terrestrial plants. Barium levels were detected above the analytical detection limits in all soil/sediment samples collected from the 43 sites at CLNWR (Appendix B, Table 2). These concentrations ranged from 21.2 mg Ba/kg dry weight at Site 23 to 276 mg Ba/kg dry weight at Site 2 (Appendix B, Table 2), all below ecological screening criteria (Shacklette and Boerngen, 1984; Efroymson *et al.*, 1997; TNRCC, 2001).

[Beryllium (Be)] Although not truly a heavy metal, beryllium is a rare element that is considered potentially toxic (Irwin and Dodson, 1991; Manahan, 1991). The distribution of beryllium in the environment largely results from the combustion of coal and oil (Goyer, 1991; Manahan, 1991). Coal mined from the mid-west U.S. contains an average of about 2.5 mg Be/kg while crude oil can contain approximately 0.08 mg Be/kg (Goyer, 1991). Beryllium concentrations in soils in the U.S. can range up to 15 mg Be/kg (Shacklette and Boerngen, 1984), however according to Shacklette and Boerngen (1984), the estimated arithmetic mean for background beryllium concentrations in soils in the western U.S. is 0.97 mg Be/kg. In the State of Texas, a soil-beryllium concentration of 1.5 mg Be/kg dry weight is considered background (TNRCC, 2001). The TNRCC (2001) considers a soil-beryllium concentration of 10 mg Be/kg dry weight as a benchmark value for terrestrial plants. In freshwater environments, Irwin and Dodson (1991) state that in the absence of a known source, lotic systems usually contains very low or non-detectable amounts of beryllium. Beryllium concentrations were detected above the analytical detection limits in every soil/sediment sample collected from the 43 sites at CLNWR with the exception of the sample collected from Site 8, which contained no detectable amount (Appendix B, Table 2). The detected concentrations ranged from 0.05 mg Be/kg dry weight at Site 35 to 0.96 mg Be/kg dry weight at Site 43 (Appendix B, Table 2), all below recommended screening criteria.

[Boron (B)] Boron compounds are used in the production of fertilizers and other agricultural chemicals such as herbicides and insecticides (Moore *et al.*, 1990; USDOI, 1998). In the U.S., boron concentrations in soils typically range from 10-300 mg B/kg (USDOI, 1998). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background boron concentrations in western soils is 29 mg B/kg while a soils concentration of 30 mg B/kg is considered background in the State of Texas (TNRCC, 2001). Efroymson *et al.* (1997), recommend a screening benchmark value of 20 mg B/kg dry weight for boron toxicity to soil microorganisms and microbial processes, while the TNRCC (2001) considers a soil-boron concentration of 0.5 mg B/kg dry weight as a benchmark value for terrestrial plants. Usually, arid, saline soils will contain higher boron concentrations in comparison to watered, loamy soils (USDOI, 1998). Furthermore, soils formed from marine sediments typically contain higher concentrations of boron than those formed from igneous rocks (Moore *et al.*, 1990). In aquatic systems, boron can react and bind with clays, suspended matter, and sediments (USDOI, 1998). Eisler (1990) reports that freshwater sediments with a high clay composition usually contain less than 10.0 mg B/kg dry weight. Only one of the 43 sites at CLNWR, Site 33, contained a soil/sediment-boron concentration above the analytical detection limit (Appendix B, Table 2). The measured concentration (1.06 mg B/kg dry weight) at this site exceeded the benchmark value for plants, but was below all other recommended screening criteria (Shacklette and Boerngen, 1984; Efroymson *et al.*, 1997; USDOI, 1998; TNRCC, 2001).

[Cadmium (Cd)] Ryan *et al.* (1980) reported that the normal range for elemental cadmium in surface soils in the U.S. is 0.06 to 0.5 mg Cd/kg. According to Efroymson *et al.* (1997), a proposed screening benchmark value for cadmium toxicity to soil microorganisms is 20 mg Cd/kg dry weight, while the TNRCC (2001) reports concentrations of 110 mg Cd/kg dry weight and 29 mg Cd/kg dry weight as ecological benchmarks for earthworms and terrestrial plants, respectively. In aquatic systems, elemental cadmium is insoluble in water whereas cadmium chloride, nitrate, and sulfate compounds are highly soluble in freshwater (Schneider, 1971). Cadmium toxicity in freshwater is moderated by increasing water hardness through either complexation with carbonate or competition with calcium ions (Wren *et al.*, 1995). In sediments, the OME recommends a LEL of 0.6 mg Cd/kg dry weight and a SEL of 10 mg Cd/kg dry weight (Persaud *et al.*, 1993), whereas Long *et al.* (1995), consider 1.2 mg Cd/kg dry weight as the ER-L for cadmium. MacDonald *et al.* (2000), suggest a sediment TEC of 0.99 mg Cd/kg dry weight and a PEC of 4.98 mg Cd/kg dry weight. Biologically, cadmium is neither essential nor beneficial (Hodges, 1977). Fish typically contain from 0.001 to 0.05 mg/kg of cadmium (Goyer, 1991). Although cadmium accumulates in aquatic organisms, it does not bio-magnify in succeeding trophic levels and is the only metal that clearly accumulates in increasing concentrations with the increasing age of the exposed animal (Wren *et al.*, 1995). The national 85th percentile in the U.S. for cadmium in whole body fish is 0.05 mg Cd/kg wet weight (Schmitt and Brumbaugh, 1990). A recommended predator protection limit for cadmium in potential prey items of piscivorus wildlife is 0.5 mg Cd/kg wet weight (Irwin, 1988). The tolerable limit for cadmium consumed by humans is 0.055 mg Cd/person/day (USEPA, 1994). This metal tends to concentrate in the liver, kidneys, pancreas, and thyroid gland of exposed humans with chronic exposure resulting in renal damage and neurological birth defects (Schneider, 1971; USEPA, 1994). According to Goyer (1991), daily intake in food of 0.14 to 0.16 mg Cd/day for 50 years produced renal dysfunction in adult humans. The USEPA recommended screening criterion for cadmium in fish tissues to address human health concerns is 10 mg Cd/kg wet weight (USEPA, 1995b). Of the

43 sites sampled at CLNWR, soils/sediments collected from Sites 1 through 10, 12 through 22, 24, 28, 31, and 35 contained no appreciable amounts of cadmium (Appendix B, Table 2). The measured cadmium concentrations from the remaining 18 sites ranged from 0.1 mg Cd/kg dry weight at Site 33 to 0.71 mg Cd/kg dry weight at Site 29 (Appendix B, Table 2). Only samples from two of these sites, Site 29 and Site 39, contained cadmium levels (0.71 and 0.64 mg Cd/kg dry weight, respectively) that exceeded the expected soil background concentration and the OME sediment LEL value (Ryan *et al.*, 1980; Persaud *et al.*, 1993); however, none of the detected cadmium concentrations in any of the samples collected exceeded the ER-L value recommended by Long *et al.* (1995), any of the sediment criteria proposed by MacDonald *et al.* (2000), nor any of the ecological screening criteria for soils suggested by Efroymson *et al.* (1997) and the TNRCC (2001).

[Chromium (Cr)] Excessive chromium can be mutagenic, carcinogenic, and teratogenic to a wide variety of organisms (Eisler, 1986a). Shacklette and Boerngen (1984) reported an estimated arithmetic mean of 56 mg Cr/kg as background for soils in the western U.S. According to the TNRCC (2001), a soil-chromium concentration of 30 mg Cr/kg dry weight can be considered background in the State of Texas. Efroymson *et al.* (1997), proposed soil toxicity screening benchmark values ranging from 0.4 mg Cr/kg dry weight for earthworms to 10 mg Cr/kg dry weight for soil microorganisms. The USEPA (2000a) considers a soil-chromium concentration of 5 mg Cr/kg dry weight as a benchmark value for terrestrial plants. In freshwater systems, hydrolysis and preciptation are more important physical processes in determining the fate of chromium in comparison to adsorption and bio-accumulation (Eisler, 1986). It occurs in aqueous environments in various ionic forms, including the chromous, chromic, chromite, chromate, and/or dichromate ions (Becker and Thatcher, 1973). In the chromic or chromite forms, the ions are trivalent, whereas in the chromate and dichromate forms, the ions are hexavalent (Becker and Thatcher, 1973). Overall toxicity of chromium to aquatic biota is dependent on water hardness, temperature, pH, chemical speciation, and salinity, but in general, hexavalent chromium is more toxic than trivalent chromium (Becker and Thatcher, 1973; Eisler, 1986a). According to Eisler (1986a), the majority of chromium bound in sediments is unavailable for living organisms. Molluscs accumulate chromium from contaminated sediments at comparatively low concentrations (Eisler, 1986a). The OME suggest a LEL of 26 mg Cr/kg dry weight and a SEL of 110 mg Cr/kg dry weight for chromium in sediments (Persaud *et al.*, 1993), whereas MacDonald *et al.* (2000), recommend a sediment TEC of 43.4 mg Cr/kg dry weight and a PEC of 111 mg Cr/kg dry weight. For wildlife, Eisler (1986a) recommends a piscivorus predator protection limit of 4 mg Cr/kg dry weight. In humans, chromium is essential for normal metabolism of insulin and glucose (Eisler, 1986a). The typical chromium-blood concentration in persons who have not experienced excessive exposure to chromium is 0.02-0.03 mg/L (Goyer, 1991). Toxicologically, the major immediate effect from ingested chromium is acute renal tubular necrosis (Goyer, 1991). Chromium concentrations were detected above the analytical detection limits in all soil/sediment samples collected from the 43 sites at CLNWR (Appendix B, Table 2). These concentrations ranged from 3.22 mg Cr/kg dry weight at Site 35 to 25.1 mg Cr/kg dry weight at Site 27 (Appendix B, Table 2). Samples from three of the sites (Sites 18, 33, and 35) contained chromium levels less than 5 mg Cr/kg dry weight, while samples from 13 of the sites (Sites 13, 14, 19, 20, 24, 25, 27, 29, 32, 34, 39, 41, and 43) contained chromium levels greater than 10 mg Cr/kg dry weight (Appendix B, Table 2); however, every sample collected contained chromium concentrations below suggested soil background values and sediment screening criteria (Shacklette and Boerngen, 1984; Persaud *et al.*, 1993; MacDonald *et al.*, 2000; TNRCC, 2001).

[Copper (Cu)] Copper is primarily used in the manufacturing of electrical equipment, pipe, and machinery (1998a). It is also an essential micronutrient that interacts in animals with other essential trace elements such as iron, zinc, molybdenum, manganese, nickel, and selenium and also with nonessential elements including silver, cadmium, mercury, and lead (Goyer, 1991; Eisler, 1998a). In aquatic environments, enzymes concerned with nitrate transformations in algae require copper (Horne and Goldman, 1994). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background copper concentrations in surface soils in the western U.S. is 27 mg Cu/kg, while a soil-copper concentration of 15 mg Cu/kg dry weight is considered background in the State of Texas (TNRCC, 2001). Efroymson *et al.* (1997), proposed a soils toxicity screening benchmark value of 100 mg Cu/kg dry weight. The TNRCC (2001) report 61 mg Cu/kg dry weight as the soils benchmark value for earthworms. In freshwater aquatic environments, the type and amount of various copper compounds present in the water depends on water pH, temperature, alkalinity, and on the concentrations of bicarbonate, sulfide, and organic ligands (Eisler, 1998a). The solubility of copper and copper salts is decreased under reducing conditions and is further modified by pH, temperature, and hardness; size and density of suspended materials; rates of coagulation and sedimentation of particulates; and concentration of dissolved organics (Eisler, 1998a). Copper concentrations in sediment interstitial pore waters correlate positively with concentrations of dissolved copper in the overlying water column (Eisler, 1998a). Typically, sediment bound copper is available to benthic organisms under anoxic and low pH conditions (Eisler, 1998a). The OME recommends a sediment LEL of 16 mg Cu/kg dry weight and a SEL of 110 mg Cu/kg dry weight (Persaud *et al.*, 1993), whereas Long *et al.* (1995), consider 34 mg Cu/kg dry weight as the ER-L for copper in sediments. MacDonald *et al.* (2000), suggest a sediment TEC of 31.6 mg Cu/kg dry weight and a PEC of 149 mg Cu/kg dry weight.

In general, elevated copper concentrations can be more toxic to aquatic organisms than to birds or mammals (USDOI, 1998). Bio-availability and toxicity of copper to aquatic organisms depends primarily on the total concentration of copper present and its speciation (Eisler, 1998a). Copper toxicity appears to exert its major effect on algae by interfering with the activity of enzymes situated on cell membranes (Horne and Goldman, 1994). The national 85th percentile in the U.S. as reported by Schmitt and Brumbaugh (1990), for copper in whole body fish is 1 mg Cu/kg wet weight. Bluegill collected by the USFWS in 1993 from Caddo Lake contained a $\bar{x}$ = 0.76 mg Cu/kg wet weight (Giggleman *et al.*, 1998). A recommended predator protection limit for copper in prey items for avian species and other piscivorus wildlife is 300 mg Cu/kg wet weight (NRC, 1980). In humans, acute poisoning from the ingestion of excessive amounts of copper salts may produce death (Goyer, 1991). Normal copper-blood serum levels in humans range from 120-145 µg/dl (Goyer, 1991). Severe hepatic disorders have been documented in children in the U.S. resulting from the ingestion of 10 mg Cu/10 kg child/day through contaminated milk (Goyer, 1991).

Copper concentrations were detected above the analytical detection limits in every soil/sediment sample collected at CLNWR (appendix B, Table 2). These concentrations ranged from 0.95 mg Cu/kg dry weight at Site 28 to 15 mg Cu/kg dry weight at Site 39 (Appendix B, Table 2), all equal to or below recommended screening criteria.

[Iron (Fe)] Iron is a necessary nutrient that is a constituent of many enzymatic and other cellular processes (Horne and Goldman, 1994). It is absolutely essential both for the transport of oxygen to

the tissues and for maintenance of oxidative systems within the tissue cells (Guyton, 1981). Iron composes approximately 5% of the Earth's crust (Miller and Gardiner, 1998). Background iron concentrations in surface soils in the western U.S. range up to 26,000 mg Fe/kg (Shacklette and Boerngen, 1984). In Texas, median background soil-iron concentrations are reported as 15,000 mg Fe/kg (TNRCC, 2001). Under normal oxidizing conditions in freshwater systems, ferric iron predominates over ferrous iron, and in turn, ferric iron forms insoluble compounds that rapidly disassociate from the water column and drop to the sediments (Horne and Goldman, 1994). The OME recommends a LEL of 20,000 mg Fe/kg dry weight and a SEL of 40,000 mg Fe/kg dry weight for iron in sediments (Persaud *et al.*, 1993). According to Beyer (1990), sediments from the Great Lakes containing less than 17,000 mg Fe/kg dry weight are considered non-polluted, whereas sediments containing iron concentrations greater than 25,000 mg Fe/kg dry weight are considered extremely polluted.

Most animals acquire iron directly from their diet (Horne and Goldman, 1994). A recommended predator protection limit in prey items for wildlife is 1000.0 mg Fe/kg wet weight (NRC, 1980). The human body contains approximately 3 to 5 grams of iron of which about 33% is bound to hemoglobin, 10 % is bound to myoglobin and iron containing enzymes, and the remainder is bound to the iron storage proteins ferritin and hemosiderin (Goyer, 1991). The required daily intake to maintain homeostasis in the average human body is 18 mg Fe/day (Guyton, 1981). According to Goyer (1991), acute iron toxicity in humans is nearly always due to accidental ingestion of iron containing medicines, and most often occurs in children. Chronic iron toxicity can occur in humans due to excess dietary iron and can result in hepatic and renal disorders, endocrine disturbances, and negative cardiovascular effects (Goyer, 1991).

Iron levels were detected above the analytical detection limits in all soil/sediment samples collected from the 43 sites at CLNWR (Appendix B, Table 2). These concentrations ranged from 2, 414 mg Fe/kg dry weight at Site 35 to 28,100 mg Fe/kg dry weight at Site 19 (Appendix B, Table 2). Only Sites 19, 27 (27,190 mg Fe/kg dry weight), and 29 (24,420 mg Fe/kg dry weight) contained soil/sediment-iron concentrations greater than 20,000 mg/kg dry weight. Although elevated at these sites in comparison to certain screening criteria, iron does not appear to be causing a detrimental affect to ecological resources at CLNWR.

[Lead (Pb)] Listed by the USEPA as a priority pollutant, lead is used in pigment and chemical production, metallurgy and steel manufacturing, storage batteries, ceramics, petroleum products, cable sheathing, pipe and sheeting fabrication, and ammunition production (Eisler, 1988b). Lead is neither essential nor beneficial to living organisms, and unlike mercury, lead does not exhibit bio-magnification through progressive trophic levels (Eisler, 1988b; Pain 1995). Lead is naturally occurring in soils. According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background lead concentrations in surface soils in the western U.S. is 20 mg Pb/kg. The TNRCC (2001), considers a soil-lead concentration of 15 mg Pb/kg dry weight as background in the State of Texas. Soil benchmark values range from 50 mg Pb/kg dry weight for terrestrial plants to 500 mg Pb/kg dry weight for earthworms (TNRCC, 2001). In water, lead is most soluble and bio-available under conditions of low pH, low organic content, low concentrations of suspended sediments, and low concentrations of calcium, iron, manganese, zinc, and cadmium salts (Eisler, 1988b). Depending on the concentration, lead can adversely affect survival, growth, and/or

reproduction in all fish species (Eisler, 1988b). The national 85th percentile concentration in whole body fish as reported by Schmitt and Brumbaugh (1990), is 0.22 mg Pb/kg wet weight. The deposition of lead to sediments in aqueous environments is attributed primarily to the strong binding capacities of many sediment components for metals (Pain, 1995). In turn, lead concentrations in aquatic plants have been directly correlated with sediment lead concentrations (Pain, 1995). The OME suggests a sediment LEL of 31 mg Pb/kg dry weight and a SEL of 250 mg Pb/kg dry weight (Persaud *et al.*, 1993), while Long *et al.* (1995), consider 47 mg Pb/kg dry weight as the ER-L for lead in sediments. MacDonald *et al.* (2000), suggest a sediment TEC of 35.8 mg Pb/kg dry weight and a PEC of 128 mg Pb/kg dry weight.

The National Research Council (1980), recommends a fish whole body lead concentration of 50 mg Pb/kg wet weight as an appropriate level to assure the protection of avian predators and other piscivorus wildlife. In humans, food is the principal route of exposure to lead (Goyer, 1991). The average dietary intake of adult humans in the U.S. is 0.1 mg Pb/day (Goyer, 1991). Adults absorb from 5%-15% of ingested lead but usually retain less than 5% of what is absorbed; however, children demonstrate a greater affinity for the absorption of lead than adults (Goyer, 1991). In adults, the toxic effects of lead can involve several organ systems, whereas in children the critical effects typically involve the central nervous system (Goyer, 1991). *In utero* neurological effects occur at maternal lead-blood serum levels of less than 15 µg/dl (Goyer, 1991). Peripheral neuropathy occurs in both adults and children at lead-blood serum concentrations of 40 µg/dl, while academic performance (i.e., I.Q.) deficits occur in children with lead-blood serum levels of less than 30 µg/dl (Goyer, 1991). The action level for establishing fish consumption advisories in the U.S. for lead in fish tissues is 1.3 mg Pb/kg, while the Canadian action level for human consumption advisories is initiated when lead concentrations are greater than or equal to 0.5 mg Pb/kg wet weight in fish tissues (USEPA, 1989; USEPA, 1997).

Lead was detected above the analytical detection limits in every soil/sediment sample collected from CLNWR (Appendix B, Table 2). These concentrations ranged from 1.52 mg Pb/kg dry weight at Site 35 to 78.2 mg Pb/kg dry weight at Site 20 (Appendix B, Table 2). Detected soil/sediment lead levels at six sites [Site 6 (39.3 mg Pb/kg dry weight), Site 12 (20.4 mg Pb/kg dry weight), Site 19 (53.9 mg Pb/kg dry weight), Site 20, Site 25 (63.4 mg Pb/kg dry weight), and Site 29 (51.9 mg Pb/kg dry weight)] exceeded all of the recommended background criteria for soil (Shacklette and Boerngen, 1984; TNRCC, 2001). In addition, the measured concentrations at Sites 19, 20, 25, and 29 exceeded the lower soil benchmark value recommended by the TNRCC (2001) and all of the lower threshold criteria for sediments (Persaud *et al.*, 1993; Long *et al.*, 1995; MacDonald *et al.*, 2000). Based on these results, further investigation into the lead contamination at these four sites is warranted.

[Magnesium (Mg)] Magnesium is an essential nutrient that is required for energy transfer in all living cells because it catalyzes the change from adenosine triphosphate (ATP) to adenosine diphosphate (ADP) (Horne and Goldman, 1994). The Earth's crust is composed of approximately 2.1% magnesium (Miller and Gardiner, 1998). Shacklette and Boerngen (1984), estimated the arithmetic mean for background magnesium concentrations in surface soils in the western U.S. as 10,000 mg Mg/kg. Along with calcium, magnesium is one of the two most common polyvalent metallic ions found in freshwater (Cole, 1983; Irwin and Dodson, 1991). Currently, there are no

sediment screening criteria for magnesium levels in sediments, but sediment samples collected by the USFWS in 1993 from Cypress Springs Reservoir, Lake O'The Pines, and Caddo Lake in East Texas contained mean sediment concentrations of $\bar{x}$ = 928.8 mg Mg/kg dry weight, $\bar{x}$ = 475.6 mg Mg/kg dry weight, and $\bar{x}$ = 1,148.1 mg Mg/kg dry weight, respectively (Giggleman *et al.*, 1998). A recommended predator protection limit for piscivorus avian species is 3,000 mg Mg/kg wet weight (NRC, 1980). The required daily intake to maintain homeostasis in the human body is 400 mg Mg/day (Guyton, 1981). Intoxication in humans due to the oral intake of excessive amounts of magnesium salts is rare, but may occur in the face of renal impairment (Goyer, 1991). Magnesium concentrations were detected above the analytical detection limits in all soil/sediment samples collected from the 43 sites at CLNWR (Appendix B, Table 2). These concentrations ranged from 79.7 mg Mg/kg dry weight at Site 35 to 3,306 mg Mg/kg dry weight at Site 39 (Appendix B, Table 2). Three of the sites [Site 29 (3,163 mg Mg/kg dry weight), Site 39, and Site 42 (1,274 mg Mg/kg dry weight)] contained elevated magnesium levels in comparison to the sediment concentrations reported by Giggleman *et al.* (1998) for Caddo Lake; however, none of the 43 sites sampled at CLNWR contained magnesium levels above the background soil value reported by Shacklette and Boerngen (1984).

[Manganese (Mn)] Manganese is a widely distributed, abundant element that constitutes approximately 0.085% of the earth's crust (Irwin and Dodson, 1991). It is a necessary nutrient for plants and animals that is relatively nontoxic to aquatic biota (Wiener and Giesy, 1979; Cole 1983). It stimulates planktonic growth in freshwater conditions by activating enzymatic systems (Cole, 1983). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background manganese concentrations in surface soils in the western U.S. is 480 mg Mn/kg. The TNRCC (2001), considers a soil-manganese concentration of 300 mg Mn/kg dry weight as background in the State of Texas. According to Efroymson *et al.* (1997), a proposed screening benchmark value for manganese toxicity to soil microorganisms is 100 mg Mn/kg dry weight, while the TNRCC (2001) reports a soil-manganese concentration of 500 mg Mn/kg dry weight as a benchmark value for terrestrial plants. The ecological screening benchmark recommended by the USEPA for manganese in soils is 100 mg Mn/kg (RAIS, 2002b). In sediments, the OME recommends a LEL of 460 mg Mn/kg dry weight and a SEL of 1,100 mg Mn/kg dry weight (Persaud *et al.*, 1993). Sediments from the Great Lakes containing less than 300 mg Mn/kg dry weight are considered non-polluted, whereas sediments containing manganese concentrations greater than 500 mg Mn/kg dry weight are considered heavily polluted (Beyer, 1990). A recommended predator protection limit for piscivorus avian species is 2,000 mg Mn/kg wet weight, while a recommended predator protection limit for mammalian species is 400 mg Mn/kg wet weight (NRC, 1980). In humans, manganese is an essential element that is a cofactor for a number of enzymatic reactions, but excessive exposure can produce disorders of the pulmonary, hepatic, gastrointestinal, genitourinary, and central nervous systems (Shukla and Singhal, 1984; Goyer, 1991). Normal daily intake ranges from 2.0 to 9.0 mg Mn (Goyer, 1991). Once in the body, manganese concentrates in the mitochondria of cells, so that tissues rich in these organelles, such as the pancreas, liver, kidneys, and intestines, tend to contain the highest manganese concentrations (Goyer, 1991). Acute systemic toxicity in humans due to oral intake of manganese salts is rare (Goyer, 1991). This is because the administration of large doses of these salts causes extreme gastrointestinal irritation which results in the vast majority of the manganese being rapidly passed out of the digestive system by means of the feces with very little absorption from the digestive tract occurring (Goyer, 1991). Although, continuous chronic exposure

to large amounts of manganese in drinking water has produced symptoms resembling Parkinson's Disease in humans (Shukla and Singhal, 1984).

Manganese concentrations were detected above the analytical detection limits in every soil/sediment sample collected at CLNWR (Appendix B, Table 2). The detected concentrations ranged from 12.6 mg Mn/kg dry weight at Site 35 to 1,455 mg Mn/kg dry weight at Site 5 (Appendix B, Table 2). Soils/sediments collected from Sites 1, 4, 7, 9, 15, 17, 18, 19, 21, and 26 contained manganese levels (Appendix B, Table 2) greater than 500 mg Mn/kg dry weight. Samples collected from Sites 2, 11, and 13 contained manganese concentrations (Appendix B, Table 2) greater than 900 mg Mn/kg dry weight, while the measured concentrations at Site 5, Site 6 (1,048 mg Mn/kg dry weight), and Site 29 (1,171 mg Mn/kg dry weight) were highly elevated in comparison to screening criteria. Based on these results, further investigation is warranted at these 16 sites to define the extent of manganese contamination within these areas as well as determine the effects this contamination has on ecological resources.

[Mercury (Hg)] Mercury has been used in metallurgy, the preparation of dental amalgams, in switches, thermometers, barometers, pharmaceuticals, and in the electrolytic preparation of chlorine (Eisler, 1987). It was also used in anti-fouling and mildew proofing of paints and controlling fungal diseases in plants (Eisler, 1987). Major anthropogenic sources of mercury include pulp and paper mills, mining and reprocessing of metallic ores, and the incomplete combustion of fossil fuels (Eisler, 1987). Mercury can exist in many forms in an aquatic environment, including elemental mercury, dissolved and particulate ionic forms, and/or to a lesser extent, dissolved and particulate methylmercury (Wiener and Spry, 1996). The production of methylmercury by methylation of inorganic mercury in the sediments and the water column of an aqueous environment is dependent on microbial activity, nutrient content, pH, salinity, oxidation-reduction conditions, and alkalinity (Eisler, 1987; Wiener and Spry, 1996; Alpers and Hunerlach, 2000). In soils, background surface soil-mercury concentrations in the western U.S. are typically less than or equal to 0.065 mg Hg/kg (Shacklette and Boerngen, 1984). In the State of Texas, a soil-mercury concentration of 0.04 is considered background (TNRCC, 2001). The TNRCC (2001) recommends soil-mercury concentrations of 0.1 mg Hg/kg dry weight as a benchmark value for earthworms and 0.3 mg Hg/kg dry weight as a benchmark value for terrestrial plants. In surface water systems exposed to mercury influxes, methylmercury is generally found in sediments that, although subject to anoxic or sub-oxic conditions, have limited sulfate availability (Jaffe *et al.*, 1997). Typical concentrations of mercury in benthic invertebrates from uncontaminated sediments are generally less than 0.1 mg Hg/kg wet weight (Wren *et al.*, 1995). The OME suggest a sediment LEL of 0.2 mg Hg/kg dry weight and a SEL of 2 mg Hg/kg dry weight (Persaud *et al.*, 1993), while Long *et al.* (1995), recommend 0.15 mg Hg/kg dry weight as the ER-L for mercury in sediments. MacDonald *et al.* (2000), suggest a sediment TEC of 0.18 mg Hg/kg dry weight and a PEC of 1.06 mg Hg/kg dry weight.

Schmitt and Brumbaugh (1990) state that the national 85th percentile for mercury in whole body fish in the U.S. is 0.17 mg Hg/kg wet weight. In fish, 95% to 99% of the mercury present is in the form of methylmercury even though very little of the total mercury found in water and sediments may exist as methylmercury (Wiener and Spry, 1996). This is because fish tend to obtain the majority of methylmercury from their diet and to a lesser extent, from water passing over the gills (Wiener and Spry, 1996). Furthermore, methylmercury concentrations in predaceous fish are typically

elevated in comparison to prey species because methylmercury content can increase by a factor of ten or less with each successive trophic level through the process known as bio-magnification (Alpers and Hunerlach, 2000). Methylmercury is toxic and has no known essential function in vertebrate organisms (Eisler, 1987). Eisler (1987), recommends an avian predator protection limit of 0.1 mg Hg/kg wet weight and a mammalian predator protection limit of 1.1 mg Hg/kg wet weight. Human exposure to methylmercury is primarily due to consumption of contaminated fish (Wiener and Spry, 1996). In humans, methylmercury has a greater affinity for the brain, particularly the posterior cortex, than any other organ system (Goyer, 1991). Major human health concerns include neurotoxic effects to adults and children, and toxicity to the fetus of mothers exposed during pregnancy (Goyer, 1991). Genotoxic effects can occur during prenatal development resulting in chromosomal aberrations in the fetus due to methylmercury interacting with fetal deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) and binding with sulfhydryl groups resulting in changes of the secondary structure of DNA and RNA synthesis (Goyer, 1991). In adults, the overall acute effect is cerebral edema with the onset of paresthesia (numbness and tingling sensations around the lips, fingers, and toes), but chronic exposure can lead to the destruction of grey matter and cerebral atrophy (Goyer, 1991; USFDA, 1995). Children suffering from prenatal exposure typically demonstrate psychomotor retardation, but may also develop ataxis motor disturbances and mental symptoms similar to cerebral palsy (Goyer, 1991). The average mercury concentration in the blood and hair of non-exposed people is 8 μg/L and 2 mg Hg/kg, respectively, whereas toxic effects are expected in people who have mercury-blood concentrations of 2000 μg Hg/L and mercury-hair levels of 50 mg Hg/kg (USFDA, 1995). According to Goyer (1991), the estimated average long-term daily intake associated with adverse health effects in an adult is 4.3 μg Hg/day/kg of body weight while adverse prenatal effects are expected at maternal intake concentrations of 0.8 to 1.7 μg Hg/day/kg of body weight. The USFDA has established an action level of 1.0 mg Hg/kg wet weight for total mercury in fish tissues for initiating fish consumption advisories to protect public health (USEPA, 1989). In comparison, the USEPA (2001a), recommends a tissue residue criterion of 0.3 mg Hg/kg wet weight to be protective of human health. A typical human-fish consumption advisory based on elevated mercury content consists of establishing consumption limits for particular sectors of the population over a given period of time. For example, the advisory established by the State of Texas at Caddo Lake states that adults should consume no more than two meals, not to exceed 8 ounces (226.8 grams) of fish per serving, per month, whereas children should consume no more than two meals per month, not to exceed 4 ounces (113.4 grams) of fish per serving (TDH, 1997). For an additional comparison, the USFDA (1995) recommends that persons other than pregnant women and women of child bearing age who may become pregnant consume no more than 7 ounces (198.5 grams) of fish per week when mercury levels in fish are detected at 1 mg Hg/kg. For fish with mercury levels averaging 0.5 mg Hg/kg, the USFDA (1995) recommends that regular consumption should be limited to no more than 14 ounces (396.9 grams) per week.

Mercury concentrations were detected above the analytical detection limits at CLNWR in soils/sediments collected from Sites 22, 25, 26, 27, 29 and 31 (Appendix B, Table 2). The measured concentrations ranged from 0.06 mg Hg/kg dry weight at Sites 22 and 31 to 0.26 mg Hg/kg dry weight at Site 26 (Appendix B, Table 2). The concentrations detected at Sites 25 (0.17 mg Hg/kg dry weight), 26, 27 (0.15 mg Hg/kg dry weight), and 29 (0.12 mg Hg/kg dry weight) exceeded background values and the soil benchmark value for earthworms recommended by the TNRCC. In addition, the mercury content in samples collected from Sites 25 and 27 equaled or exceeded the ER-

L value for sediments but was below the TEC and LEL values. The sample from Site 26 exceeded all the lower threshold sediment criteria and approached the terrestrial plant-soil benchmark value suggested by the TNRCC. Based on these results, the mercury contamination appears to be spatially related to a possible point source and further investigation to determine the extent and effect to ecological resources from this contamination at Sites 25, 26, 27, and 29 is warranted.

[Molybdenum (Mo)] Molybdenum is a comparatively rare element that does not occur free in nature and is usually found in conjunction with sulfur, oxygen, tungsten, lead, uranium, iron, magnesium, cobalt, vanadium, bismuth, or calcium (Eisler, 1989). It is an essential micronutrient for most life forms; however, excessive exposure can result in toxicity to both animals and humans (Goyer, 1991; USDOI, 1998). This metal is necessary for fixing atmospheric nitrogen by bacteria in plants (Goyer, 1991). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background molybdenum concentrations in surface soils in the western U.S. is 1.1 mg Mo/kg. Efroymson *et al.* (1997), proposed a soils toxicity screening benchmark value of 200 mg Mo/kg dry weight for soil microorganisms, while the TNRCC (2001) considers a soils concentration of 2 mg Mo/kg as the benchmark value for terrestrial plants. The largest soil-molybdenum concentrations are usually found within the top 30 cm of surface soils (USDOI, 1998). Ionic forms of molybdenum such as molybdate, tend to be sorbed most readily in alkaline soils which are high in calcium and chlorides, whereas retention is limited in low pH and low sulfate soils (Eisler, 1989). In freshwater at a pH greater than 7, molybdenum exists primarily as the molybdate ion, whereas at a pH less than 7, various polymeric compounds are formed, including the paramolybdate ion (Eisler, 1989). Aquatic organisms are relatively resistant to molybdenum (USDOI, 1998). Background concentrations in lotic sediments in the U.S. range from 5 to 57 mg Mo/kg dry weight (USDOI, 1998). Sediment samples collected by the USFWS in 1993 from Cypress Springs Reservoir, Lake O'The Pines, and Caddo Lake in East Texas contained no detectable molybdenum concentrations (Giggleman *et al.*, 1998). A recommended predator protection limit for molybdenum in prey items for mammals is 10 mg Mo/kg wet weight and 100 mg Mo/kg wet weight for predaceous avian species (NRC, 1980). Pastures containing between 20-100 mg Mo/kg may produce a disease in grazing animals known as teart (molybdenosis) which can prove fatal (Goyer, 1991). The average daily intake by humans in food is approximately 0.35 mg (Goyer, 1991). Normal molybdenum-blood concentrations in people averages approximately 14.7 µg Mo/L (Eisler, 1989). The recommended dietary intake for humans is less than 7 µg Mo/kg food, based on a 70 kg adult (Eisler, 1989). Only soil/sediment samples collected from Sites 21, 25, 33, and 42 at CLNWR contained molybdenum levels above the analytical detection limits (Appendix B, Table 2). These concentrations ranged from 0.52 mg Mo/kg dry weight at Site 42 to 0.57 mg Mo/kg dry weight at Site 25 (Appendix B, Table 2), all below screening criteria.

[Nickel (Ni)] Background surface soil-nickel concentrations range up to 19 mg Ni/kg in the western U.S. and up to 10 mg Ni/kg in the State of Texas (Shacklette and Boerngen, 1984; TNRCC, 2001). According to Efroymson *et al.* (1997), a proposed screening benchmark value for nickel toxicity to soil microorganisms is 90 mg Ni/kg dry weight, while the TNRCC (2001) reports a soil-nickel concentration of 30 mg Ni/kg dry weight as a benchmark value for terrestrial plants. The physical and chemical forms of nickel and its salts strongly influence its bio-availability and toxicity in aqueous environments (Eisler, 1998b). In freshwater, nickel occurs as soluble salts adsorbed onto clay particles and organic matter (Eisler, 1998b). The distribution of nickel in an aquatic

environment can be affected by pH, ionic strength, and availability of solid surfaces for adsorption (Eisler, 1998b). Sediment samples collected adjacent to a nickel smelter in Canada contained nickel concentrations as high as 5,000 mg Ni/kg dry weight, whereas sediments collected from lakes in the Rocky Mountains in the U.S. with no known sources other than background, contained nickel concentrations ranging from 10 to 18 mg Ni/kg dry weight (Eisler, 1998b). The OME recommends a sediment LEL of 16 mg Ni/kg dry weight and a SEL of 75 mg Ni/kg dry weight (Persaud *et al.*, 1993), whereas Long *et al.* (1995), recommend 21 mg Ni/kg dry weight as the ER-L for nickel in sediments. MacDonald *et al.* (2000), suggest a sediment TEC of 22.7 mg Ni/kg dry weight and a PEC of 48.6 mg Ni/kg dry weight.

In mammals, dietary nickel is poorly absorbed and relatively nontoxic (Law, 1996). The National Research Council (1980) considers 100 mg Ni/kg wet weight as the predator protection limit for nickel in prey items. Some forms of nickel can be carcinogenic to humans, however, this carcinogenisis is primarily attributed to inhalation of nickel compounds typically associated with the nickel refining industry (Goyer, 1991; Eisler, 1998b). Nickel entering the digestive tract in humans is likely to be non-carcinogenic (Eisler, 1998b). Dietary nickel intake by adults in the U.S. is estimated to be 0.3-0.6 mg/day (Goyer, 1991). The action level for nickel residues in fish tissues recommended by the USFDA is 70 mg Ni/kg (USEPA, 1997).

With the exception of Site 35, nickel concentrations were detected above the analytical detection limits in all soil/sediment samples collected from CLNWR (Appendix B, Table 2). The detected concentrations ranged from 0.96 mg Ni/kg dry weight at Site 37 to 28.3 mg Ni/kg dry weight at Site 29 (Appendix B, Table 2). Only the samples collected from Sites 29 and 39 (25.8 mg Ni/kg dry weight) contained nickel levels that exceeded any of the ecological benchmark values, but the concentrations detected at these sites were not at levels where significant adverse affects to wildlife resources would be expected to occur.

[Selenium (Se)] Selenium is an essential micronutrient but like other necessary dietary minerals, elevated levels can have detrimental effects on exposed organisms. It typically exists in nature and biologic systems as either selenate, selenite, elemental selenium, and/or selenide (Eisler, 1985b; Goyer, 1991). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background selenium concentrations in surface soils in the western U.S. is 0.34 mg Se/kg. The TNRCC (2001), considers a soil-selenium concentration of 0.3 mg Se/kg dry weight as background in the State of Texas. Selenium volatilizes from soils and sediments at rates that are modified by temperature, moisture, time, season of year, concentration of water soluble selenium, and microbial activity (Eisler, 1985b). The TNRCC (2001) reports soil-selenium concentrations of 1 mg Se/kg dry weight as a benchmark value for terrestrial plants and 70 mg Se/kg as a benchmark value for earthworms. In an aqueous environment, selenium concentrations in water are a function of selenium levels contained within the drainage system and water pH (Eisler, 1985b). In sediments, elemental selenium has a tendency to predominate in reducing environments (Van Derveer and Canton, 1997). According to Van Derveer and Canton (1997), the predicted effects concentration of selenium in sediments would be 2.5 mg Se/kg, while the observed effects threshold for fish and wildlife toxicity would be 4 mg Se/kg. The national 85th percentile for selenium in whole body fish in the U.S. as reported by Schmitt and Brumbaugh (1990), is 0.73 mg Se/kg wet weight. Reproductive failure has been observed in bluegills with whole body selenium concentrations greater

than16 mg Se/kg dry weight, while teratogenic effects have been observed in bluegills with whole body selenium concentrations of 15 mg Se/kg dry weight (Lemly, 1996). In humans, selenium is probably not carcinogenic, however it can be considered embryotoxic and teratogenic (Goyer, 1991). Normal human dietary levels range from 0.04 to 0.1 mg/kg of selenium, with 0.2 mg Se/day being the recommended maximum safe intake for adults (Eisler, 1985b; Goyer, 1991). Toxicological effects are expected to occur when food-selenium concentrations approach 4 mg Se/kg (Eisler, 1985b).

Selenium levels above the analytical detection limits were measured at CLNWR only at Sites 1, 4, 5, 13, 20, 24, 27, and 42 (Appendix B, Table 2). The detected concentrations at Site 1 (0.73 mg Se/kg dry weight), Site 5 (0.87 mg Se/kg dry weight), Site 6 (0.65 mg Se/kg dry weight), Site 13 (0.62 mg Se/kg dry weight), Site 20 (0.57 mg Se/kg dry weight), Site 27 (0.59 mg Se/kg dry weight), and Site 42 (0.67 mg Se/kg dry weight) exceeded suggested background levels but were below levels where adverse ecological effects would be expected to occur. The detected selenium concentration at Site 24 (8.57 mg Se/kg dry weight) exceeded all of the lower threshold criteria but was well less than the soil benchmark value recommended for earthworms by the TNRCC (2001).

[Silver (Ag)] Silver and its compounds have a wide variety of industrial uses. They were used at the former Longhorn Army Ammunition Plant in x-rays and photographic materials (Tolbert, personal communication, 2002). In aqueous environments, adsoprtion is the dominant process involved in partitioning silver onto sediments (Warrington, 1996). According to Warrington (1996), silver concentrations of lotic sediments in mineralized areas average 0.93 mg Ag/kg, while sediments from non-mineralized areas contain approximately 0.14 mg Ag/kg. Silver concentrations in sediments from U.S. streams can range from 0.3 to 1.5 mg Ag/kg (Warrington, 1996). However, according to Buchman (1999), background sediment-silver concentrations are typically less than 0.5 mg Ag/kg. In Texas, the TNRCC (2001) recommends a concentration of 1 mg Ag/kg dry weight as the ecological benchmark value for sediments. In soils, Efroymson *et al.* (1997), proposed a toxicity screening benchmark value of 50 mg Ag/kg dry weight for soil microorganisms, while the TNRCC (2001) considers a soil-silver concentration of 2 mg Ag/kg dry weight as a benchmark value for terrestrial plants. Silver was measured above the analytical detection limit at CLNWR in soil/sediment samples collected from Sites 1 through 7, 9 through 11, 14 through 20, and 38 (Appendix B, Table 2). With the exception of the level measured at Site 38, silver concentrations detected at CLNWR were below all screening criteria and benchmark values. The detected concentration at Site 38 (1.16 mg Ag/kg dry weight) slightly exceeded the sediment criterion but was below all soil benchmark values.

[Strontium (Sr)] Strontium compounds are used in the manufacturing of pyrotechnics including signal flares and tracer bullets, the production of glass and ceramics, and sugar refining (Merck, 1989). Strontium is a fairly common alkaline earth metal (Irwin and Dodson, 1991). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background strontium concentrations in western soils in the U.S. is 270 mg Sr/kg while a soils concentration of 100 mg Sr/kg is considered background in the State of Texas (TNRCC, 2001). In localities where it is abundant, like calcium, strontium is an important freshwater quality ion that contributes to water hardness (Irwin and Dodson, 1991). NOAA considers 49 mg Sr/kg dry weight to be the background level for strontium in freshwater sediments (Buchman, 1999). Strontium concentrations were

detected above the analytical detection limits in every soil/sediment sample collected from CLNWR (Appendix B, Table 2). These concentrations ranged from 1.79 mg Sr/kg dry weight at Site 23 to 63.2 mg Sr/kg dry weight at Site 29 (Appendix B, Table 2). All of the measured levels were below the suggested background values for soils, while only the sample from Site 29 exceeded the NOAA sediment criterion.

[Vanadium (V)] Approximately 0.01% of the Earth's crust is composed of vanadium (Merck, 1989). Vanadium compounds are used in the production of rust-resistant metals, the manufacturing of ammunition, in x-rays, as catalysts in the distillation of alcohols and the production of synthetic rubber, and to reduce mercuric and ferric salts to mercurous and ferrous salts in industrial processes (Sax and Lewis, 1987; Merck, 1989). Vanadium is also a component of fossil fuels (Merck, 1989; ETC, 2000). West Texas Intermediate Crude contains approximately 3.2 mg V/L (ETC, 2000). Vanadium concentrations in soils in the U.S. can range up to 500 mg V/kg (Shacklette and Boerngen, 1984). The estimated arithmetic mean for background vanadium concentrations in western soils in the U.S. according to Shacklette and Boerngen (1984), is 88 mg V/kg, while a soils concentration of 50 mg V/kg dry weight is considered background in the State of Texas (TNRCC, 2001). The ecological screening benchmark recommended by the USEPA for vanadium in soils is 2 mg V/kg (RAIS, 2002b). According to Efroymson *et al.* (1997), a proposed screening benchmark value for vanadium toxicity to soil microorganisms is 20 mg V/kg, while the TNRCC (2001) considers a soil-vanadium concentration of 2 mg V/kg dry weight as a benchmark value for terrestrial plants. A sediment-vanadium concentration of 50 mg V/kg dry weight is considered by NOAA to be the background value in freshwater sediments (Buchman, 1999). Vanadium concentrations were detected above the analytical detection limits in all soil/sediment samples collected from the 43 sites at CLNWR (Appendix B, Table 2). The detected concentrations ranged from 4.57 mg V/kg dry weight at Site 33 to 43.5 mg V/kg dry weight at Site 19 (Appendix B, Table2). All of the sites sampled contained vanadium concentrations that exceeded the USEPA and TNRCC ecological benchmark values for soils. However, only Sites 6 (23.6 mg V/kg dry weight), 13 (30.7 mg V/kg dry weight),19, 25 (21.5 mg V/kg dry weight), 27 (39 mg V/kg dry weight), 29 (23.3 mg V/kg dry weight), 39 (20.4 mg V/kg dry weight), 41 (30.5 mg V/kg dry weight), 42 (22.1 mg V/kg dry weight), and 43 (34.2 mg V/kg dry weight) exceeded the screening criterion proposed by Efroymson *et al.*, while none of the sites sampled contained vanadium levels that exceeded recommended soil/sediment background values. Considering that the samples exceeded benchmark values, further investigation is warranted to determine if a site-related gradient exists for vanadium contamination at CLNWR.

[Zinc (Zn)] Zinc is a naturally occurring metallic element found in soil but is also listed by the USEPA as a priority pollutant (Giggleman *et al.*; 1998). It is used in the production of non-corrosive alloys and brass and in galvanizing steel and iron products (Eisler, 1993). Shacklette and Boerngen (1984), estimated the arithmetic mean for background zinc concentrations in surface soils in the western U.S. at 65 mg Zn/kg. The TNRCC (2001), considers a soil-zinc concentration of 30 mg Zn/kg as background in the State of Texas. Efroymson *et al.* (1997), proposed a soils toxicity screening benchmark value of 100 mg Zn/kg dry weight for soil microorganisms and invertebrates. The ecological screening benchmark recommended by the USEPA for zinc in soils is 50 mg Zn/kg (RAIS, 2002b). According to Eisler (1993), the majority of zinc introduced into an aquatic environment is partitioned into the sediment. Bio-availability of zinc from sediments is enhanced

under conditions of high dissolved oxygen, low salinity, low pH, and high levels of inorganic oxides and humic substances (Eisler, 1993). Sediment-zinc concentrations less than 90 mg Zn/kg dry weight are considered supportive of aquatic biota, whereas zinc concentrations greater than 200 mg Zn/kg dry weight can be harmful to aquatic biota (Eisler, 1993). The OME recommends a sediment LEL of 120 mg Zn/kg dry weight and a SEL of 820 mg Zn/kg dry weight (Persaud *et al.*, 1993), while Long *et al.* (1995), consider 150 mg Zn/kg dry weight as the ER-L for zinc in sediments. MacDonald *et al.* (2000), suggest a sediment TEC of 121 mg Zn/kg dry weight and a PEC of 459 mg Zn/kg dry weight. Zinc is a nutritionally essential metal that can be harmful to exposed organisms at elevated levels (Goyer, 1991; USDOI, 1998). It serves as an activator in enzymatic reactions in freshwater algae (Horne and Goldman, 1994). It is more toxic in aqueous environments to fish under conditions of low dissolved oxygen, high sodium concentrations, decreased loading of organic complexing agents, and low pH (Eisler, 1993). The national 85th percentile concentration for zinc in whole body fish in the U.S. reported by Schmitt and Brumbaugh (1990) is 34.2 mg Zn/kg wet weight. According to Eisler (1993), an adequate diet for avian species should contain a zinc concentration between 93 to120 mg Zn/kg dry weight, whereas a zinc diet concentration greater than 178 mg Zn/kg dry weight is excessive and could produce detrimental effects. Zinc toxicosis in humans is not a common medical problem with most poisonings being attributed to the consumption of foods or beverages which were stored for lengthy periods in galvanized (zinc coated) containers or from use of galvanized eating utensils (Goyer, 1991; Eisler, 1993). In the U.S. the average daily intake of zinc by adults is estimated at 12-15 mg Zn (Goyer, 1991).

Zinc concentrations were detected above the analytical detection limits in all soil/sediment samples collected from CLNWR, with the exception of the sample collected from Site 16, which contained no detectable amounts of zinc (Appendix B, Table 2). These concentrations ranged from 2.02 mg Zn/kg dry weight at Site 35 to 92.4 mg Zn/kg dry weight at Site 29 (Appendix B, Table 2). None of the samples analyzed contained zinc concentrations that exceeded the recommended sediment screening criteria. Seven of the sites (Sites 19, 20, 25, 27, 29, 39, and 42) contained zinc concentrations (Appendix B, Table 2) that exceeded the soils background concentration suggested for the State of Texas (TNRCC, 2001), however only three sites (Sites 19, 29, and 39) contained zinc levels (Appendix B, Table 2) that exceeded the soils benchmark value recommended by the USEPA (RAIS, 2002b). The detected concentrations at these three sites (70.5 mg Zn/kg dry weight at Site 19, 92.4 mg Zn/kg dry weight at Site 29, and 86.4 mg Zn/kg dry weight at Site 39) were still below the benchmark values recommended for soil microorganisms and invertebrates (Efroymson *et al.*, 1997).

Semi-volatile Organic Compounds

[1-Naphthylamine] Listed by Oxford University (2002) as a suspected human carcinogen, 1-naphthylamine (also known as α-naphthylamine) is used as an intermediate in the manufacture of dyes, pesticides, and as an antioxidant in the rubber industry (Sax and Lewis, 1987; EHP, 2002). This compound can be released into the environment by the break down of organic compounds in the waste stream of industrial processes; by the microbial degradation of herbicides; and by the combustion of fuels containing high nitrogen content (Spectrum, 2002a). The soil half-life for 1-naphthylamine is estimated to exceed 1 year (Spectrum, 2002a). This compound was detected above the analytical detection limit at only one site, Site 14 (Appendix B, Table 3). Currently, no screening criteria are available for 1-naphthylamine for comparative purposes; however, the detected

concentration at Site 14 (0.236 mg/kg dry weight) only exceeded the analytical detection limit by 3%. Considering this point combined with the lack of supportive toxicological information, 1-naphthylamine does not appear to represent a concern for wildlife resources at CLNWR.

[2-Nitroaniline] Also known as o-nitroaniline, 2-nitroaniline is an intermediate component of dyes and photographic anti-fogging agents (Sax and Lewis, 1987). This compound may also be found in the environment as a microbial decomposition product of the explosive dinitrobenzene (Spectrum 2002b). Of the 43 sites sampled, only soils/sediments collected from Site 14 contained a 2-nitroaniline concentration above the analytical detection limit (Appendix B, Table 3). The detected concentration at this site (0.542 mg/kg dry weight) exceeded the State of Louisiana soils screening standard for non-industrial sites (0.11 mg/kg) and the soil cleanup level recommended by the State of New York to protect groundwater quality (0.43 mg/kg) (AEHS, 2000; NYSDEC, 2002). However, this concentration was well below the State of Louisiana soils screening standard for protection of groundwater (1.7 mg/kg) and the State of Arizona recommended soil remediation level for residential sites (3.9 mg/kg) (AEHS, 2000; AAC, 2000).

Organochlorine Pesticides

[1,2,3,4-Tetrachlorobenzene] Used as an ingredient in dielectric fluids and pesticides, 1,2,3,4-tetrachlorobenzene is highly toxic to aquatic organisms and is considered a suspected teratogen (Sax and Lewis, 1987). The interim water quality guideline for the protection of aquatic life in Canada is 1.8 µg/L (Cavendish Analytical, 2001). Buchman (1999) reports a remedial target value for agricultural soils as 0.10 mg/kg for residual chlorobenzenes as a group. The ecological screening benchmark recommended by the USEPA for 1,2,3,4-tetrachlorobenzene in soils is 0.01 mg/kg, while the Oak Ridge National Laboratory considers a soils-1,2,3,4-tetrachlorobenzene concentration of 10 mg/kg as a benchmark value protective of soil invertebrates (RAIS, 2002b). This compound was detected above the analytical detection limit at two sites (Sites 14 and 16), and the detected concentrations at these sites (0.000204 mg/kg dry weight at both sites) were below the recommended benchmark values.

[1,2,4,5-Tetrachlorobenzene] Listed by the USEPA as a persistent, bio-accumulative, and toxic chemical (PBT), 1,2,4,5-tetrachlorobenzene is a common component of many herbicides, insecticides, defoliants, and electrical insulation fluids (Sax and Lewis, 1987; NDDH, 2002). In freshwater, the federal water quality criterion for the protection of human health through the consumption of aquatic organisms is 0.0029 mg/L (RAIS, 2002a). The 85th percentile screening criterion for sediments in freshwater lotic systems in Texas is 0.67 mg/kg dry weight (TNRCC, 2000). Buchman (1999) reports a remedial target value for agricultural soils as 0.10 mg/kg for residual chlorobenzenes as a group. According to the U.S. Department of Defense (2002), a 1,2,4,5-tetrachlorobenzenesoil concentration of 16.0 mg/kg represents a non-cancer exposure endpoint for humans, whereas the New Mexico Environment Department (2000), recommends a non-cancer screening value of 0.16 mg/kg for construction site soils and a screening value of 18.0 mg/kg for residential soils. This compound was detected above the analytical detection limit in soils collected from every site with the exception of Sites 6, 7, 18, 30, 32, and 34 - 43 (Appendix B, Table 4). The detected concentrations ranged from 0.000162 mg/kg dry weight at Site 10 to 0.00309 mg/kg dry weight at Site 29 (Appendix B, Table 4), all of which were below the recommended screening criteria.

[Aldrin] Considered by the USEPA as a probable human carcinogen, aldrin was used as a pesticide in the United States from 1950 through 1970 (ATSDR, 1993). In 1974 the USEPA banned all uses of dieldrin except for subterranean termite control (ATSDR, 1993). In 1987, the USEPA banned all commercial uses of this compound in the United Sates (ATSDR, 1993). Once in the environment, aldrin readily breaks down to the epoxide dieldrin through microbial and photic degradation (ATSDR, 1993; Cornell, 1998). The ecological screening benchmark recommended by the USEPA for aldrin in soils is 0.0025 mg/kg (RAIS, 2002b). The OME recommends a sediment LEL of 0.002 mg/kg dry weight and a SEL of 0.08 mg/kg dry weight (Persaud *et al.*, 1993). Aldrin was detected above the analytical limit only at one site (Site 25), and this concentration (0.000412 mg/kg dry weight) was below any of the recommended screening criteria.

[Chlordane, isomers, and metabolites)] Technical chlordane consists of the stereoisomers alpha (α) and gamma (γ) or *cis* and *trans*-chlordane, heptachlor, *cis*-nonachlor and *trans*-nonachlor, and the metabolites oxychlordane and heptachlor epoxide (ATSDR, 1994). First developed in 1946, chlordane was used as a general pesticide until 1983 (LMF, 2002). Between 1983 and 1988, use of chlordane in the United States was restricted by the USEPA to subterranean termite control (ATSDR, 1994). All commercial use of chlordane as a pesticide was banned by the USEPA in the United States in 1988 (ATSDR, 1994). In the environment, chlordane binds tightly with soil particles and can remain in the soil for more than 20 years (LMF, 2002). It can bio-accumulate in the tissues of fish, birds, and mammals and can adversely affect the nervous, digestive, and hepatic systems in both humans and animals (ATSDR, 1994; LMF, 2002). The maximum contaminant level (MCL)

Figure 3. Total chlordane values in mg/kg dry weight for 11 sites at Caddo Lake National Wildlife Refuge calculated using the sum of α- and γchlordane, *cis*- and *trans*-nonachlor, oxychlordane, heptachlor, and heptachlor epoxide concentrations in mg/kg dry weight for each site (bdl is below the analytical detection limit).

Site	α chlordane	γ chlordane	*cis*-nonachlor	*trans*-nonachlor	oxy-chlordane	Heptachlor	Heptachlor epoxide	**Total chlordane**
4	0.00182	0.00046	bdl	0.00015	bdl	bdl	bdl	**0.0024**
9	0.00074	bdl	bdl	bdl	bdl	bdl	bdl	**0.00074**
13	0.00018	bdl	bdl	bdl	bdl	bdl	bdl	**0.00018**
14	0.00351	0.00083	0.00258	0.00042	bdl	bdl	0.00020	**0.0075**
15	0.00181	0.00042	0.00087	bdl	bdl	bdl	bdl	**0.0031**
16	0.00022	bdl	bdl	bdl	bdl	bdl	bdl	**0.00022**
18	0.00076	bdl	0.00028	bdl	bdl	bdl	bdl	**0.0010**
19	0.0132	0.0124	0.0115	0.0272	0.00346	0.00020	0.00131	**0.0693**
20	0.00057	0.00026	0.00168	0.00370	0.00043	bdl	bdl	**0.0066**
25	0.00184	bdl	0.00338	0.00103	bdl	bdl	bdl	**0.0063**
29	0.00113	bdl	0.000814	bdl	bdl	bdl	bdl	**0.0019**
40	0.00047	bdl	0.00067	bdl	bdl	bdl	bdl	**0.0011**
43	bdl	0.00042	bdl	bdl	bdl	bdl	bdl	**0.00042**

for drinking water is 0.002 mg/L (Nowell and Resek, 1994). The screening criterion in Ontario for chlordane in coarse textured agricultural, residential, and parkland soils is 0.29 mg/kg (EPT, 1999). The OME reports a no effect level of total chlordane in sediments as 0.005 mg/kg dry weight and recommends a LEL of 0.007 mg/kg dry weight and a SEL of 6 mg/kg dry weight (Persaud *et al.*, 1993). Chlordane residues (isomers and/or metabolites) were detected above the analytical detection limits at Sites 4, 9, 13, 14, 15, 16, 18, 19, 20, 25, 29, 40, and 43 (Appendix B, Table 4). These concentrations were used following Munn and Gruber (1997) to calculate the total chlordane concentrations (sum of α- and γchlordane, *cis*- and *trans*-nonachlor, oxychlordane, heptachlor, and heptachlor epoxide) for each of the 13 sites (Figure 3). None of the calculated total chlordane values exceeded the recommended soil benchmark concentration. The total concentrations at Sites 14 and 19 exceeded the recommended LEL value, but were well below the SEL criterion.

[Dichloro-diphenyl-trichloroethane (DDT), isomers, and metabolites] First developed in 1939, dichloro-diphenyl-trichloroethane (DDT) was used extensively throughout the world as an insecticide (ATSDR, 1995). Considered a probable human carcinogen by the USEPA, commercial production of DDT was banned in the United States in 1972 because of adverse affects to non-target wildlife species and the potential harm to human health (ATSDR, 1995; ATSDR, 2000a). The metabolites dichloro-diphenyl-dichloroethane (DDD) and dichloro-diphenyl-dichloroethylene (DDE) are microbial degradation products formed by the dehydrohalogenation of DDT (ATSDR, 2000a). In wildlife, DDT exposure has resulted in birds, alligators, and turtles producing eggs with shells too thin for offspring survival (Baskin, 2002). This compound exhibits very low solubility in aqueous environments and bio-accumulates in the fatty tissues of fish, birds, and other animals (Baskin, 2002). In soils, DDT binds readily to soil particles with a half life estimated at 2 to 15 years (ATSDR, 1995). The screening criterion in Ontario for DDD, DDE, and DDT for coarse textured agricultural, residential, and parkland soils is 2.2, 1.6, and 1.6 mg/kg, respectively (EPT, 1999). The CCME recommends a soils-DDT screening criterion of 0.7 mg/kg for agricultural, residential, and parkland soils (EPT, 1999). According to the TNRCC (2001), the recommended sediment ecological benchmarks for DDD, DDE, and DDT are 0.00354, 0.00142, and 0.00119 mg/kg dry weight, respectively. For total-DDT, the USEPA recommends a soils screening criterion of 0.0025 mg/kg, while the TNRCC considers a sediment concentration of 0.007 mg/kg as the ecological benchmark (TNRCC, 2001; RAIS, 2002b). One or both of the DDD isomers were detected above the analytical detection limits at 23 sites (Sites 4, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31, and 43) (Appendix B, Table 3). One or both of the isomers of the metabolite DDE were detected above the analytical detection limits at 36 sites (Sites 1-4, 8-16, 18-26, 28-34, 36, 39-40, and 42-43) (Appendix B, Table 3). One or both of the isomers of the parent compound DDT were detected above the analytical detection limits at 14 sites (Sites 4, 10, 12, 13, 14, 15, 16, 18, 19, 20, 22, 25, 29, and 43) (Appendix B, Table 3). For screening purposes, the sum of the detected isomer concentrations of DDD (o,p'-DDD + p,p'-DDD), DDE (o,p'-DDE + p,p'-DDE), and/or DDT (o,p'-DDT + p,p'-DDT) were calculated following Munn and Gruber (1997) for each site where detected above the analytical detection limits (Figure 4). In addition, total-DDT concentrations were calculated for Sites 4, 10, 12, 13, 14, 15, 16, 18, 19, 20, 22, 25, 29, and 43 by adding the sum of DDD, DDE, and DDT for each of these sites (Figure 4). None of the sites sampled contained individual isomeric DDD, DDE, and/or DDT concentrations that exceeded the soil screening criteria.

Figure 4. Calculated DDD (DDD_{sum}), DDE (DDE_{sum}), DDT (DDT_{sum}), and Total DDT (DDT_{Total}) values in mg/kg dry weight for 27 sites at Caddo Lake National Wildlife Refuge (bdl is below the analytical detection limit; and NC is not calculated because DDD, DDE, and/or DDT were not all detected at the site).

Site	DDD_{sum}	DDE_{sum}	DDT_{sum}	DDT_{Total}
1	bdl	0.000662	bdl	NC
2	bdl	0.000718	bdl	NC
3	bdl	0.000209	bdl	NC
4	0.000414	0.010700	0.000534	0.01165
8	bdl	0.000251	bdl	NC
9	bdl	0.004960	bdl	NC
10	0.000387	0.000364	0.000188	0.00094
11	0.000238	0.000194	bdl	NC
12	0.000418	0.000864	0.000481	0.00176
13	0.000331	0.000503	0.000374	0.00121
14	0.004104	0.032428	0.001205	0.03774
15	0.001652	0.011035	0.000307	0.01299
16	0.000324	0.002001	0.000191	0.00252
17	0.000353	bdl	bdl	NC
18	0.000637	0.002324	0.000264	0.00323
19	0.015010	0.152740	0.049900	0.21770
20	0.006470	0.191080	0.047100	0.24470
21	0.000725	0.000375	bdl	NC
22	0.001471	0.002170	0.002389	0.00603
23	0.000681	0.001070	bdl	NC
24	0.000822	0.000301	bdl	NC
25	0.013190	0.312320	0.019060	0.34457
26	0.000856	0.000450	bdl	NC
27	0.000886	bdl	bdl	NC
28	0.000946	0.000897	bdl	NC
29	0.001700	0.005460	0.000810	0.00797
30	bdl	0.000483	bdl	NC
31	0.000795	0.002740	bdl	NC
32	bdl	0.001360	bdl	NC
33	bdl	0.001040	bdl	NC
34	bdl	0.000383	bdl	NC
36	bdl	0.000877	bdl	NC
39	bdl	0.000915	bdl	NC
40	bdl	0.004040	bdl	NC
42	bdl	0.001920	bdl	NC
43	0.081400	0.042110	0.064418	0.18793

Sites 14, 19, 20, 25, and 43 contained DDD concentrations that exceeded the sediment benchmark value. Samples collected from Sites 4, 9, 14, 15, 16, 18, 19, 20, 22, 25, 29, 31, 40, 42, and 43 contained DDE levels that exceeded the sediment criterion recommended by the TNRCC.

Calculated individual DDT values exceeded the recommended sediment criterion at Sites 14, 19, 20, 22, 25, and 43. Total-DDT concentrations equaled or exceeded the soil benchmark criterion at Sites 4, 14, 15, 16, 18, 19, 20, 22, 25, 29, and 43 and exceeded the sediment screening value at Sites 4, 14, 15, 19, 20, 25, 29, and 43. The levels of total DDT measured at CLNWR indicate that further investigations are warranted to determine the affects to wildlife resources, especially at Sites 4, 14, 15, 19, 20, 25, 29, and 43.

[Dieldrin] Dieldrin is a synthetic cyclic hydrocarbon that demonstrates high toxicity and is persistent in soils (Cornell, 1998). It is formed as a degradation product of aldrin (Cornell, 1998). From 1950 through 1970, dieldrin was used in the United States as a pesticide (ATSDR, 1993). In 1974 the USEPA banned all uses of dieldrin except for termite control (ATSDR, 1993). In 1987, the USEPA banned all commercial uses of this compound in the United Sates (ATSDR, 1993). In the environment, dieldrin degrades very slowly and binds tightly to soil and sediment particles (ATSDR, 1993). In soils, the 95% disappearance rate is 5 to 25 years (Cornell, 1998). Soil persistence is affected by soil type, with soils high in organic matter demonstrating higher persistency than sandy soils (Cornell, 1998). The ecological screening benchmark recommended by the USEPA for dieldrin in soils is 0.0005 mg/kg (RAIS, 2002b). The OME reports a no effect level of dieldrin in sediments as 0.0006 mg/kg dry weight and recommends a LEL of 0.002 mg/kg dry weight and a SEL of 91 mg/kg dry weight (Persaud *et al.*, 1993). Dieldrin concentrations were detected above the analytical detection limit at CLNWR in samples collected from Sites 12, 19, and 25 (Appendix B, Table 4). The detected concentrations ranged from 0.000239 mg/kg dry weight at Site 12 to 0.00111 mg/kg dry weight at Site 25 (Appendix B, Table 4). The levels measured at Sites 12 and 19 were below the ecological screening criteria, whereas the dieldrin concentration detected at Site 25 exceeded the soil benchmark value but was below the LEL.

[Endosulfan] The organochlorine pesticide endosulfan was first introduced in the United States in 1954, however it has not been commercially produced in the United States since 1982 (ATSDR, 2000b). This compound exits as two principal isomers, α- and β-endosulfan (ATSDR, 2000b). Endosulfan can degrade in the environment through photolysis, bio-transformation, or oxidation into the metabolite, endosulfan sulfate (ATSDR, 2000b). The screening criterion in Ontario for endosulfan in coarse textured agricultural, residential, and parkland soils is 0.18 mg/kg (EPT, 1999). In Texas, the 85th percentile screening value reported for endosulfan in freshwater sediments is 0.0107 mg/kg dry weight (TNRCC, 2000). Endosulfan concentrations were detected above the analytical detection limit at CLNWR in soil/sediment samples collected from Sites 10, 13, 14, 15, 16, 18, 19, 20, 25 and 29 (Appendix B, Table 4). The detected concentrations ranged from 0.000164 mg/kg dry weight at Site 10 to 0.00695 mg/kg dry weight at Site 25 (Appendix B, Table 4), all below ecological screening criteria.

[Endrin] Endrin is a stereoisomer of dieldrin (ATSDR, 1996). It was first used as an insecticide, rodenticide, and avicide in 1951 (ATSDR, 1996). Manufacturing of this compound discontinued in the United States in 1991 primarily because of its toxicity to non-target populations of raptors and migratory birds (ATSDR, 1996). The ecological screening benchmark recommended by the USEPA for endrin in soils is 0.001 mg/kg (RAIS, 2002b). The OME reports a no effect level of endrin in sediments as 0.0005 mg/kg dry weight and recommends a LEL of 0.003 mg/kg dry weight and a SEL of 130 mg/kg dry weight (Persaud *et al.*, 1993). Endrin was detected above the analytical detection limits in samples collected from Sites 14, 15, 18, 19, and 20 (Appendix B, Table 4). The

detected concentrations ranged from 0.000149 mg/kg dry weight at Site 18 to 0.000240 mg/kg dry weight at Site 20 (Appendix B, Table 4), all below ecological benchmark values.

[Heptachlor/Heptachlor epoxide] Developed in 1946, heptachlor is an organochlorine cyclodiene pesticide formerly used to kill termites (ETN, 1996a; NSC, 2002). It is also present as an impurity in the pesticide chlordane (NSC, 2002). Both heptachlor and heptachlor epoxide are highly persistent in soils (ETN, 1996a). The half life of heptachlor in temperate soils can be two years, however it has been detected in soils in trace amounts 14 to 16 years after application (ETN, 1996a; EMS, 2000). Heptachlor can evaporate from soil surfaces and is degraded by bacteria once it passes into the soil (USEPA, 2002). In contrast, heptachlor epoxide is not produced commercially, but rather is formed by the chemical and biological transformation of heptachlor in the environment (USEPA, 2002). This compound is not very susceptible to bio-degradation, photolysis, oxidation, or hydrolysis in the environment, consequently it can persist for many years in the upper soil layers (ETN, 1996a; USEPA, 2002). In 1988, the sale of all heptachlor products was banned in the United States by the USEPA while use of this pesticide was restricted to the control of fire ants in buried, pad-mounted electric power transformers and underground cable television and telephone cable boxes (EMS, 2000; USEPA, 2002). In humans acute exposure can lead to liver and central nervous system damage while chronic exposure can result in extensive liver damage and cancer (USEPA, 2002). The MCL established by the USEPA for heptachlor in drinking water is 0.0004 mg/L, while the MCL for heptachlor epoxide is 0.0002 mg/L (Nowell and Resek, 1994). In Ontario, the screening criterion for heptachlor in medium to fine textured agricultural, residential, and parkland soils is 0.12 mg/kg and 0.084 mg/kg for coarse textured soils (EPT, 1999). The screening criterion for heptachlor epoxide in coarse textured agricultural, residential, and parkland soils is 0.06 mg/kg (EPT, 1999). In sediments, the no effect level for heptachlor as reported by the OME is 0.0003 mg/kg dry weight, whereas the recommended LEL for heptachlor epoxide is 0.005 mg/kg dry weight and the SEL is 5 mg/kg dry weight (Persaud *et al.*, 1993). Heptachlor was detected above the analytical detection limit only at one site, while heptachlor epoxide was detected above the analytical detection limit at Site 14 and Site 19 (Appendix B, Table 4). The detected heptachlor epoxide concentration at Site 14 (0.000199 mg/kg dry weight) and the detected heptachlor and heptachlor epoxide concentrations at Site 19 (0.000195 mg/kg dry weight and 0.00131 mg/kg dry weight, respectively) were below the screening criteria for soils and sediments.

[Hexachlorobenzene (HCB)] First introduced in 1945, hexachlorobenzene was widely used in the United States as a fungicide (ATSDR, 1997; EMS 2002a). It was also used in the manufacturing of fireworks, ammunition, and synthetic rubber, and can be produced as a by-product in the waste streams of chloralkali and wood-preserving plants and the incineration of industrial and municipal solid wastes (ATSDR, 1997). Production of HCB as a fungicide ceased in 1965 and currently there are no commercial uses for this compound in the United States (ATSDR, 1997). Hexachlorobenzene is highly persistent in soils, with reported half lives ranging from 2.7 to 22.9 years (ETN, 1996b; EMS, 2002a). At the surface, evaporation is rapid, but once HCB is mixed into the soil, this process slows down considerably (ETN, 1996b). Hexachlorobenzene exhibits low water solubility, but once it is released into an aquatic environment it can rapidly degrade into pentachlorophenol and related compounds (ETN, 1996b; ATSDR, 1997; EMS, 2002a). This compound is a suspected carcinogen and is toxic to fish and avian species, while chronic exposure in humans can lead to liver disease and cancer (ATSDR, 1997; EMS, 2002a). The MCL established by the USEPA for HCB in drinking water is 0.001 mg/L (ATSDR, 1997). The no effect level for HCB in sediments as reported by the

OME is 0.01 mg/kg dry weight, whereas the recommended sediment LEL is 0.02 mg/kg dry weight and the SEL is 24 mg/kg dry weight (Persaud *et al.*, 1993). The ecological screening benchmark recommended by the USEPA for hexachlorobenzene in soils is 0.0025 mg/kg, while the Oak Ridge National Laboratory considers a soils-HCB concentration of 1000 mg/kg as a benchmark value protective of soil microorganisms (RAIS, 2002b). In Canada, a soils-HCB concentration of 0.1 mg/kg is considered background, while an HCB concentration of 1.0 mg.kg is indicative of moderate soil contamination (Beyer, 1990). Of the samples collected from CLNWR, only Sites 9, 11, 15, and 19 contained HCB levels above the analytical detection limits (Appendix B, Table 4). The detected concentrations ranged from 0.000160 mg/kg dry weight at Site 15 to 0.000389 mg/kg dry weight at Site 19 (Appendix B, Table 4), all below the recommended benchmark values.

[alpha-, beta-, and gamma-Hexachlorocyclohexane (αBHC, βBHC, and γBHC)] Hexachlorocyclohexane represents a group of manufactured chemicals used in pesticides that do not occur naturally in the environment (ATSDR, 1999a). Eight isomers are formed from hexachlorocyclohexane of which the four most common are alpha-, beta-, delta-, and gamma-BHC (ATSDR, 1999a). In the United States, the commercial production of γBHC, also known as lindane, began in 1945 (EHP, 2002). This compound was used extensively in the 1950s as an insecticide in the timber industry but is no longer produced commercially in the United States (ATSDR, 1999a; EHP, 2002). The commercial production of all hexachlorocyclohexane pesticides in the United States ceased after 1983 (EHP, 2002). In soils, hexachlorocyclohexane can degrade rapidly under anaerobic conditions but is considered extremely persistent in upland soils (Damborsky *et al.*, 2002). Under aerobic conditions, bio-degradation mineralizes αBHC and γBHC, whereas βBHC persists (Middeldorp and McLeish, 2002). Anaerobically, βBHC can biodegrade in soils to benzene and chlorobenzene (Middeldorp and McLeish, 2002). In aquatic environments, hexachlorocyclohexane can become absorbed and adsorbed to sediments and broken down biologically by microflora and fauna (ETN, 1993). It can accumulate in the fatty tissue of fish, birds, and mammals (ETN, 1993; ATSDR, 1999a). Lindane is highly toxic to fish and aquatic invertebrates and may cause birth defects in amphibians (ETN, 1993). Hexachlorocyclohexane and its isomers are reasonably anticipated to be human carcinogens (EHP, 2002). The MCL established by the USEPA for lindane in drinking water is 0.0002 mg/L (ATSDR, 1999a). The ecological screening benchmarks recommended by the USEPA for αBHC, βBHC, and γBHC in soils are as follows: 0.0025 mg/kg, 0.001 mg/kg, and 0.00005 mg/kg (RAIS, 2002b). Screening values for αBHC, βBHC, and γBHC in sediments are 0.006 mg/kg dry weight, 0.005 mg/kg dry weight, and 0.00094 mg/kg dry weight, respectively (USEPA VI, 2001). Of the samples analyzed, only Site 19 contained αBHC and γBHC concentrations above the analytical detection limits, while the sample collected from Site 14 was the only one that contained a βBHC level above the analytical detection limit (Appendix B, Table 4). The detected αBHC concentration at Site 19 (0.000188 mg/kg dry weight) and the βBHC concentration at Site 14 (0.000641 mg/kg dry weight) were below their respective soil and sediment benchmark values, whereas the detected γBHC concentration at Site 19 (0.000223 mg/kg dry weight) exceeded the soil screening criterion but was below the sediment screening value.

[Mirex] First developed in 1946, the pesticide mirex is a highly stable chlorinated hydrocarbon compound that exhibits very low solubility in water and is highly resistant to chemical, thermal, and biochemical degradation (Eisler, 1985a). From 1959 to 1972, mirex was used to control fire ants and as a flame retardant in plastics, rubber, paint, paper, and electrical goods (Eco-USA, 2002). It has not been produced are used in the United States since 1978 (Eco-USA, 2002). Because of its

resistance to degradation, mirex has a half-life of over 10 years in terrestrial soils and aquatic sediments (Eisler, 1985a; EMS, 2002b). Mirex concentrations detected in sediments from Lake Ontario may continue to remain bio-available for 200 to 600 years (Eisler, 1985a). Listed by the USEPA as PBT, mirex is a known endocrine disruptor and suspected carcinogen (Eco-USA, 2002; EMS, 2002b). A limit of 0.000001 mg/L has been established in surface water to protect fish and other aquatic organisms from harmful effects (Eco-USA, 2002). The OME recommends a sediment LEL of 0.007 mg/kg dry weight and a SEL of 130 mg/kg dry weight (Persaud *et al.*, 1993). Mirex was detected above the analytical detection limit in samples collected from only one site at CLNWR, Site 20 (Appendix B, Table 4). Although soil benchmark values for this compound have not been established, the detected concentration at Site 20 (0.000503 mg/kg dry weight) was well below the screening criterion for sediments.

[Pentachloroanisole] A suspected carcinogen, pentachloroanisole is a chlorinated aromatic compound that is widely distributed in the environment (NTP, 2002). It is formed as a degradation product of pentachloronitrobenzene and pentachlorophenol (NTP, 2002). Pentachloroanisole concentrations were detected above the analytical detection limits in soils/sediments collected from Sites 1, 9, 12, 13, 15, 16, 18, 19, 20, 36, and 39 (Appendix B, Table 4). These detected concentrations ranged from 0.000163 mg/kg dry weight at Site 20 to 0.00925 mg/kg dry weight at Site 13 (Appendix B, Table 4). Currently, there are no screening criteria available for pentachloroanisole in sediments and/or soils. However, there are criteria available for its parent compound, pentachlorophenol which is used as a pesticide and wood preservative. The ecological screening benchmark recommended by the USEPA for pentachlorophenol in soils is 0.002 mg/kg, while the Oak Ridge National Laboratory considers a soils-pentachlorophenol concentration of 3 mg/kg as a benchmark value protective of plants (RAIS, 2002b). In sediments, the State of Washington considers a pentachlorophenol concentration of 0.36 mg/kg as an apparent effects threshold level (RAIS, 2002b). With the exception of the pentachloroanisole concentrations detected at Sites 13 and 36 (0.00487 mg/kg dry weight), all of the other sites contained pentachloroanisole concentrations below the soil screening criterion recommended by the USEPA for pentachlorophenol. The pentachloroanisole concentrations at Sites 13 and 36 exceeded this criterion but were below the pentachlorophenol soil criterion recommended by the Oak Ridge National Laboratory and the sediment pentachlorophenol criterion proposed by the State of Washington.

Polychlorinated Biphenyls

[Total Polychlorinated Biphenyls (PCBs)] Polychlorinated biphenyls were used extensively in electrical transformers, capacitors, heat transfer fluids, and electrical utilities as lubricants, insulators, and coolants until production was banned in 1979 (USEPA, 1994; Moring, 1997). Total PCBs represents a quantification of approximately 209 individual congeners (Moring, 1997). These congeners are relatively stable compounds that exhibit low water solubilities, high heat capacities, low flammabilities, low electric conductivities, and low vapor pressures (USEPA, 1994; Moring, 1997). In wildlife, PCBs can be teratogenic and tumorigenic and demonstrate a trend to bio-accumulate and bio-magnify in succeeding trophic levels. In fish, PCBs are stored in fat, liver, and brain tissue, but can be found in trace amounts in all tissues. According to Eisler (1986b), total PCB concentrations greater than 0.4 mg/kg wet weight in whole body fish and greater than 3 mg/kg in the diet of avian species would result in lethal and/or sublethal toxicological affects. Studies cited by Niimi (1996), suggest that PCB concentrations greater than 25 mg/kg wet weight in

macroinvertebrates and greater than 50 mg/kg wet weight in fish tissues may adversely affect reproduction and growth. The ecological screening benchmark recommended by the USEPA for total PCBs in soils is 0.02 mg/kg, while the Oak Ridge National Laboratory considers a soils-total PCBs concentration of 40 mg/kg as a benchmark value protective of plants (RAIS, 2002b). The Canadian Council of Ministers of the Environment (CCME) recommends a soils-total PCBs concentration of 0.3 mg/kg as the screening criterion for agricultural, residential, and parkland soils (EPT, 1999). According to Buchman (1999), NOAA considers a soils-total PCBs concentration of 0.5 mg/kg dry weight as the target value for remedial efforts in agricultural soils and a concentration of 5 mg/kg dry weight as the target value for remedial activities in urban park/residential soils. The OME suggest a sediment LEL of 0.07 mg/kg dry weight and a SEL of 5.3 mg/kg dry weight (Persaud *et al.*, 1993), while Long *et al*. (1995), consider 0.05 mg/kg dry weight as the ER-L for total PCBs in sediments. MacDonald *et al*. (2000), recommend a sediment TEC of 0.06 mg/kg dry weight and a sediment PEC of 0.68 mg/kg dry weight. Total-PCBs were detected in all of the soil/sediment samples collected from CLNWR (Appendix B, Table 4). The measured concentrations ranged from 0.00146 mg/kg dry weight at Site 37 to 0.633 mg/kg dry weight at Site 25 (Appendix B, Table 4). Concentrations measured at Sites 4, 13, 14, 15, 19, 20, 26, 29, 32, 34, 36, and 43 (Appendix B, Table 4) equaled or exceeded the soil benchmark value recommended by the USEPA but were below the screening criterion recommended by the CCME, the remedial target values recommended by NOAA, and well below the screening criterion protective of plants suggested by Oak Ridge National Laboratory. Measured concentrations at Sites 14, 20, and 32 (Appendix B, Table 4) exceeded the ER-L value for sediments but were below the LEL value. Sites 19 and 36 contained levels that exceeded the TEC, ER-L, and LEL values for sediments, but were below the SEL and PEC values. Total-PCBs measured at Site 25 exceeded the USEPA soils benchmark value, the screening criterion recommended by the CCME, the remedial target value for agricultural soils recommended by NOAA, the sediment LEL, TEC, and ER-L values, and approached the sediment PEC; however, the measured concentration at Site 25 was below the NOAA remedial target value for urban park/residential soils, the SEL value for sediments, and well below the screening criterion protective of plants recommended by Oak Ridge National Laboratory. However, considering the bio-accumulative propensity of PCBs in succeeding feeding guilds the concentration detected at Site 25 may warrant further investigation.

Dioxins/Furans

[Dioxins/Furans] There are 75 polychlorinated dibenzodioxin compounds classified as dioxins and 135 polychlorinated dibenzofuran compounds categorized as furans (ATSDR, 1999b; CHEJ, 1999). Of these compounds, seven dioxins and 10 furans exhibit dioxin-like toxicity (CHEJ, 1999). These compounds can be released into the environment as unintentional by-products of the incineration of chlorinated municipal and industrial wastes (CHEJ, 1999; USEPA, 2000). Once these compounds are released into the environment they are fairly resistant to degradation and thus tend to be persistent (McArleton *et al.*, 2001).

In aquatic systems, dioxins can bind readily to sediment particles because of their low water solubilities (Rice and O'Keefe, 1995). Although all dioxin-like compounds are thought to act in the same manner, they are not equally toxic (CHEJ, 1999). The compound 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is considered to be the most toxic of the dioxins (ATSDR, 1999b; CHEJ, 1999). Consequently, the health risk of each dioxin-like compound is assessed by rating its toxicity in

comparison to TCDD (CHEJ, 1999). The compound TCDD is assigned a value of 1 while each of the remaining16 toxic dioxins/furans is assigned a toxicity factor that estimates its toxicity relative to TCDD with the resulting estimates being designated as toxic equivalency factors (TEFs) (USEPA, 1998; CHEJ, 1999). The TEFs (Figure 5) are then used to determine the toxic equivalency (TEQ) of the compound by multiplying the concentration of the given dioxin-like compound with its corresponding TEF (CHEJ, 1999). The total TEQ of a given sample can then be calculated by adding up all of the individual TEQ values for that sample (CHEJ, 1999). The World Health Organization has determined that TCDD is a human carcinogen (ATSDR, 1999b), while the U.S. Environmental Protection Agency (USEPA) considers the other dioxins as likely human carcinogens (USEPA, 2001b). In humans, acute exposure to dioxins has resulted in chloracne, liver toxicity, skin rashes, nausea, vomiting, and muscular aches and pains (EDF, 2002). Symptoms of chronic exposure can include splenic and testicular atrophy, elevated cholesteral levels, and abnormal neurological responses (EDF,2002). The maximum allowable concentration of TCDD in drinking water as determined by the USEPA is 0.00003 micrograms/liter (μg/L), while the U.S. Food

Figure 5. Toxic Equivalency Factors (TEFs) of the 17 compounds that exhibit dioxin-like toxicity (USEPA, 1998).

Compound	Acronym	TEF
2,3,7,8-tetrachlorodibenzo-p-dioxin	TCDD	1.0
1,2,3,7,8-pentachlorodibenzo-p-dioxin	PeCDD	0.5
1,2,3,4,7,8-hexachlorodibenzo-p-dioxin	1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-hexachlorodibenzo-p-dioxin	1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-hexachlorodibenzo-p-dioxin	1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin	HpCDD	0.01
1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin	OCDD	0.001
2,3,7,8-tetrachlorodibenzofuran	TCDF	0.1
1,2,3,7,8-pentachlorodibenzofuran	1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-pentachlorodibenzofuran	2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-hexachlorodibenzofuran	1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-hexachlorodibenzofuran	1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-hexachlorodibenzofuran	1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-hexachlorodibenzofuran	2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-heptachlorodibenzofuran	1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-heptachlorodibenzofuran	1,2,3,4,7,8,9-HpCDF	0.01
1,2,3,4,6,7,8,9-octachlorodibenzofuran	OCDF	0.001

and Drug Administration (USFDA) recommends against eating fish and shellfish with TCDD levels greater than 0.05 μg/kg (ATSDR, 1999). Non-lethal symptoms of acute exposure to dioxins include weight loss, edema, and gastrointestinal hemorrhaging in rodents and birds, while chronic exposure has resulted in developmental and reproductive abnormalities in fish, birds, and rodents (Rice and O'Keefe, 1995). According to Harrison (1999), the OME considers a level of 0.00001 mg/kg TEQ as a soils-dioxin concentration protective of wildlife. The criterion recommended by the Wisconsin Department of Natural Resources for dioxins/furans levels within sediments in harbors of the Great Lakes is 0.000001 mg/kg dry weight (Beyer, 1990). According to Buchman (1999), NOAA considers a soils-TCDD concentration of 0.00001 mg/kg dry weight as the target value for remedial actions in agricultural soils and a concentration of 0.001 mg/kg dry weight as the target value for

remedial activities in urban park/residential soils. Of the 17 dioxin-like compounds analyzed for in the soil/sediment samples collected from five sites at CLNWR, OCDD levels were detected above the analytical detection limits at all five sites; HpCDD concentrations were detected above the analytical detection limits at Sites 5, 10, 31, and 42; 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, and 1,2,3,7,8,9-HxCDF were detected above their respective analytical detection limits at Site 42; and 1,2,3,4,6,7,8-HpCDFand OCDF were detected above their respective limits at Site 22 (Appendix B, Table 5). None of the remaining dioxin-like compounds were detected above their respective analytical detection limits. The calculated TEQ values for these five sites (Appendix B, Table 5) were below the recommended screening values for soils and sediments with the exception of Sites 31 (TEQ = 0.0000022 mg/kg dry weight) and 42 (TEQ = 0.0000091) which exceeded the Great Lakes sediment criterion.

Perchlorate

[Perchlorate (ClO_4)] Perchlorate compounds are strong oxidizers that have been widely used as additives in solid rocket propellants and ignitable sources in munitions and fireworks (Smith *et al.*, 2001; York *et al.*, 2001). In the environment, perchlorate is highly soluble in water, readily moves through both groundwater and surface water, and can persist for decades (Nzengung and Wang, 2000; Smith *et al.*, 2001). In humans, perchlorate can interfere with iodine uptake in the thyroid gland and at elevated concentrations interferes with the thyroid's ability to produce hormones and regulate metabolism (Nzengung and Wang, 2000). Nationally, the toxicological and risk characteristics of perchlorate are currently being reviewed by the USEPA. In the interim, the current action level for perchlorate in groundwater in Texas is 4 µg/L (Sher, personal communication, 2002). Of the 43 sites sampled, perchlorate was measured above the analytical detection limit at only one site, Site 1 (Appendix B, Table 2). Considering that recent studies have indicated that perchlorate bio-accumulates in plants with unknown bio-magnification potential (Smith *et al.*, 2001), combined with the lack of soil/sediment criteria or standards currently available for comparative purposes, the detected concentration at this site (269 µg/kg) warrants further investigation.

CONCLUSIONS & RECOMMENDATIONS

As would be expected, metals were detected throughout the 43 sites sampled. Five of these metals were detected at high enough concentrations to warrant further investigation: lead was detected at elevated levels at four sites (Sites 19, 20, 25, and 29); manganese was measured at elevated concentrations at 16 sites (Sites 1, 2, 4, 5, 6, 7, 9, 11, 13, 15, 17, 18, 19, 21, 26, and 29); mercury was detected at elevated levels at four sites (Sites 25, 26, 27, and 29); vanadium was measured at elevated concentrations at 10 sites (Sites 6, 13,19, 25, 27, 29, 39, 41, 42, and 43); and zinc was detected at elevated levels at three sites (Sites 19, 29, and 39). Only two semi-volatile compounds, 1-naphthylamine and 2-nitroaniline, were measured above the analytical detection limits. These compounds were detected at only one site (Site 14) and at levels where adverse affects to ecological resources would not be expected to occur. Residual organochlorine pesticides were detected throughout the western portion of the Refuge. Of these compounds, elevated total-DDT levels were measured at eight sites (Sites 4, 14, 15, 19, 20, 25, 29, and 43) at high enough concentrations that further investigation into the affects to ecological resources is warranted. Total-PCBs were detected

above the analytical detection limits at every site sampled. Dioxin/furans were detected at levels that do not appear to represent a concern for wildlife resources. Perchlorate was detected above the analytical detection limit at only one site (Site 1). Considering the sparsity of toxicological criteria currently available for perchlorate, the detected concentration at this site warrants further investigation.

In conclusion, the overall results indicated that contaminant levels were low enough at Sites 22, 23, 24, 28, and 30 through 40, that the USFWS could assume primary jurisdiction of these sites. However, at Sites 2 through 13, 15 through 18, and 21, further investigation is warranted principally because of elevated levels of metals, before the USFWS can assume responsibility for these areas. In addition, due to the perchlorate level measured at Site 1 and the detection of multiple bio-accumulative contaminants at Sites 14 (total-chlordane, total-DDT, endosulfan, endrin, heptachlor epoxide, βBHC, and total-PCBs),19 (lead, zinc, total-chlordane, total- DDT, dieldrin, endosulfan, endrin, heptachlor, heptachlor epoxide, HCB, αBHC, γBHC, pentachloroanisole, and total-PCBs), 20 (lead, total-chlordane, total-DDT, endosulfan, endrin, mirex, pentachloroanisole, and total-PCBs), 25 (lead, mercury, aldrin, total-chlordane, total-DDT, dieldrin, endosulfan, and total-PCBs), 26 (mercury and total-PCBs), 27 (mercury), 29 (lead, mercury, zinc, total-chlordane, total-DDT, endosulfan, and total-PCBs), and 43 (total-DDT and total-PCBs), further investigation and possibly remedial efforts are required prior to transfer of these areas from the U.S. Army to the USFWS.

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PERSONAL COMMUNICATIONS

Sher, J. 2002. Texas Commission on Environmental Quality. telephone: 512/239-2444

Tolbert, D. 2002. Longhorn/Louisiana Army Ammunition Plant. telephone: 318/459-5109

APPENDIX A
(ANALYTICAL METHODS)

Method Code: 003 for % Moisture, % Dry Weight
Laboratory: Geochemical Environmental Research Group, Texas A&M

Approximately 1 gram of wet sample is weighed into a clean, labeled, pre-weighed 10 ml beaker. The beaker is placed in a forced air oven at approximately 75°Celsisu for 24 hours. The beaker with the dry sample is then weighed and the % dry weight is calculated by the formula:

$$\frac{\text{(wt. dry sample and beaker) - (wt. beaker)}}{\text{(wt. wet sample and beaker) - (wt. beaker)}}(100)$$

Method Code: 004 for 1,2,3,4-terachlorobenzene, 1,2,4,5-tetrachlorobenzene, aldrin, hexachlorobenzene (HCB), heptachlor, alpha hexachlorocyclohexane (αBHC), alpha (α) chlordane, beta hexachlorocyclohexane (βBHC), cis-nonachlor, delta hexachlorocyclohexane (δBHC), dieldrin, endosulfan II, endrin, gamma hexachlorocyclohexane (γBHC), gamma (γ) chlordane, heptachlor epoxide, mirex, o,p'-dichloro-diphenyl-dichloroethane (o,p'-DDD), o,p'-dichloro-diphenyl-trichloroethane (o,p'-DDT), oxychlordane, p,p'-dichloro-diphenyl-dichloroethane (p,p'-DDD), p,p'-dichloro-diphenyl-dichloroethylene (p,p'-DDE), p,p'-dichloro-diphenyl-trichloroethane (p,p'-DDT), pentachloro-anisole, toxaphene, trans-nonachlor, and total polychlorobiphenyls (PCBs)

Laboratory: Geochemical Environmental Research Group, Texas A&M

The soil/sediment samples were freeze dried and extracted in a Soxhlet extraction apparatus. Briefly, the freeze dried soil/sediment samples were homogenized and a 10 gram sample was weighed into the extraction thimble. Surrogate standards and methylene chloride were added and the samples extracted for 12 hours. The extracts were treated with copper to remove sulfur and were purified by silica/alumina column chromatography (MacLeod *et al.*, 1985; Brooks *et al.*, 1989) to isolate the pesticide and PCB fractions. The quantative analyses were performed by capillary gas chromatography (CGC) with electron capture detector for pesticides and PCBS (Wade *et al.*, 1988). There are specific cases where analytes requested for the pesticide and PCB analyses and are known to co-elute with other analytes in the normal CGC with electron capture. These include the pesticide endosulfan I and the PCB congeners 114 and 157. In these cases, the samples were analyzed by CGC with mass spectrometer detector in the SIM mode.

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Wade, T.L., E.L. Atlas, J.M. Brooks, M.C. Kennicutt II, R.G. Fox, J. Sericano, B. Garcia, and D. DeFreitas. 1988. NOAA Gulf opf Mexico Status and Trends Program: Trace Organic Contaminant Distribution in Sediments and Oyster. Estuaries 11, pp 171-179.

Method Code: 006 for Soil/Sediment Clay, Silt, and Sand Grain Sizes
Laboratory: Geochemical Environmental Research Group, Texas A&M

A small aliquot of sediment is treated with 30% hydrogen peroxide to remove organic coating from grains. A dispersing agent is then added to the sample. The sand/mud fractions are then separated using a 63 micron sieve. The sand fraction (greater than 63 microns) is retained on the screen and the mud fraction (silt and clay less than 63 microns) is washed into a 1 liter volumetric cylinder. The sand fraction is dried, sieved on a 63 micron screen and weighed. The sediment which passes through the screen a second time is added to the 1 liter cylinder. The mud fraction is analyzed by stirring the cylinder and sampling 20 ml aliquots at 4 and 8 phi intervals. The 4 and 8 phi samples are dried and weighed. The % sand, silt, and clay fractions are determined on a dry weight basis.

Method Code: 026 for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), 1,2,3,7,8-pentachlorodibenzo-p-dioxin (PeCDD), 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin (1,2,3,4,7,8-HxCDD), 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin (1,2,3,6,7,8-HxCDD), 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin (1,2,3,7,8,9-HxCDD), 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD), 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin (OCDD), 2,3,7,8-tetrachlorodibenzofuran (TCDF), 1,2,3,7,8-pentachlorodibenzofuran (1,2,3,7,8-PeCDF), 2,3,4,7,8-pentachlorodibenzofuran (2,3,4,7,8-PeCDF), 1,2,3,4,7,8-hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF), 1,2,3,6,7,8-hexachlorodibenzofuran (1,2,3,6,7,8-HxCDF), 1,2,3,7,8,9-hexachlorodibenzofuran (1,2,3,7,8,9-HxCDF), 2,3,4,6,7,8-hexachlorodibenzofuran (2,3,4,6,7,8-HxCDF), 1,2,3,4,6,7,8-heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF), 1,2,3,4,7,8,9-heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF), and 1,2,3,4,6,7,8,9-octachlorodibenzofuran (OCDF)
Laboratory: Geochemical % Environmental Research Group, Texas A&M

The procedure uses matrix specific extraction, analyte specific cleanup, and HRGC/HRMS analysis techniques. If interferences are encountered, the method provides selected cleanup

procedures to aid in their elimination. A specified amount of the sample matrix is spiked with a solution containing each of 15 isotopically (13C12) labeled PCDDs/PCDFs. The sample is then extracted according to a matrix specific extraction procedure. Aqueous samples that are judged to contain 1% or more solids, and solid samples that show an aqueous phase, are filtered, the soil phase and the aqueous phase extracted separately, and the extracts combined before cleanup. Following a solvent exchange step, the extracts are cleaned up by column chromatography on alumina, silica gel, and AX-21 activated carbon on silica. The preparation of the final extract for HRGA/HRMS analysis is accomplished by adding 2 isotopically (13C12) labeled recovery standards. 2 µl of the concentrated extracts were injected into an HRGC/HRMS system capable of performing selected ion monitoring at resolving powers of at least 10,000 (10% valley definition). The identification of the 16 2378-substituted isomers for which a 13C-labeled standard is available is based on their elution at their exact retention time and the simultaneous detection of the two most abundant ions in the molecular ion region. The identification of OCDF is based on its retention time relative to 13C-OCDD. Confirmation is based on a comparison of the ratios of the integrated ion abundance of the molecular ion species to their theoretical abundance ratios. Qunatitation of the individual congeners is achieved in conjunction with the establishment of a multipoint calibartion curve for each homologue, during which, each calibration solution is analyzed once.

References: Tondeur, Y. 1987. Method 8290: Analytical Procedures and Quality Assurance for Multimedia Analysis of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans by High resolution Gas Chromatography/High Resolution Mass Spectrometry (Revision 0, November 1990). USEPA EMSL. Las Vegas, Nevada.

USEPA. 1990. Method 1613: Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS. Office of Water Regulation and Standards, Industrial Technology Division.

Method Code: 031 for 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1-chloronaphthalene, 1-naphthylamine, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2,4-dinitrotoluene, 2,6-dichlorophenol, 2,6-dinitrotoluene, 2-chloronaphthalene, 2-chlorophenol, 2-methylphenol, 2-naphthylamine, 2-nitroaniline, 2-nitrophenol, 2-picoline, 2-methylnaphthalene, 3,3'-dichlorobenzidine, 3-methylcholanthrene, 3-nitroaniline, 4,6-dinitro-2-methylphenol, 4-aminobiphenyl, 4-bromophenyl-phenylether, 4-chloro-3-methylphenol, 4-chloroaniline, 4-chlorophenyl-phenylether, 4-methylphenol, 4-nitrophenol, 7,12-dimethylbenz(a)anthracene, acentophenone, aniline, benzidine, benzo(a)anthracene, benzoic acid, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate, bis(2chloroisopropy)ether, butylbenzylphthalate, carbazole, di-n-

butylphthalate, di-n-octylphthalate, dibenz(a,h)anthracene, dibenz(a,j)acridine, dibenzofuran, diethyl phthalate, dimethylphthalate, diphenylamine, ethyl methanesulfonate, hexachlorobutadiene, hexachlorocyclopentadiene, hexachloroethane, isophorone, methyl methanesulfonate, n-nitroso-di-n-propylamine, n-nitrosopiperidine, nitrobenzene, pentachlorobenzene, pentachloronitrobenzene, pentachlorophenol, phenacetin, phenol, pronamide, a,a-dimethylphenylamine, acenaphthalene, acenaphthene, anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, n-nitrosodiphenylamine, naphthalene, p-dimethylaminoazobenzene, phenanthrene, and pyrene

Laboratory: Geochemical % Environmental Research Group, Texas A&M

The soil/sediment samples are dried with sodium sulfate; surrogate standards are added and the soil/sediment sample is extracted with methylene chloride in an Accelarated Solvent Extraction (ASE) apparatus. Copper is added to remove elemental sulfur. The quantitative analyses were performed by capillary gas chromatography (GC) with a mass spectrometer detector in the SCAN mode for semivolatile hydrocarbons (EPA Contract Laboratory for Organic Analyses OLM04.2 and EPA 8270). The compound list is based on the EPA CLP protocol but analytes from SW846 Method 8270 have been added.

References: Qian, Y., J.L. Sericano, and T.L. Wade. 1998. Extraction Tissues for Trace Organic Analysis. In Sampling and Analytical Methods of the National Status and Trends Program Mussel Watch Project: 1993-1996 Update. G.G. Lauenstein and A.Y. Cantillo, eds. NOAA Technical Memorandum NOS ORCA 130. pp 98-101.

USEPA. USEPA Contract Laboratory Program Statement of Work for Organic Analysis. OLM04.2.

Method Codes: 001, 004, and 006 for aluminum, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, strontium, vanadium, and zinc.

Laboratory: Research Triangle Institute

Homogenization (001) - Soil/sediment samples are pre-homogenized using a food processor. A portion of the sample is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.

Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement (004) - Using a CEM microwave oven, 0.25 to 0.5 grams of freeze dried sample are heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and 15 minutes at 450 watts. The residue is

then diluted to 50 ml with laboratory pure water.

ICP (006) - ICP measurements are made using a Leeman Labs Plasma Spec 1 sequential or ES2000 simultaneous spectrometer.

Method Codes: 001, 004, and 007 for arsenic and selenium.
Laboratory: Research Triangle Institute

Homogenization (001) - Soil/sediment samples are pre-homogenized using a food processor. A portion of the sample is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.

Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement (004) - Using a CEM microwave oven, 0.25 to 0.5 grams of freeze dried sample are heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and 15 minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.

GFAA (007) - GFAA measurements are made using a Perkin-Elmer Zeeman 3030 or 4100ZL atomic absorption spectrometer.

Method Codes: 001, 004, and 008 for mercury.
Laboratory: Research Triangle Institute

Homogenization (001) - Soil/sediment samples are pre-homogenized using a food processor. A portion of the sample is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.

Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement (004) - Using a CEM microwave oven, 0.25 to 0.5 grams of freeze dried sample are heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and 15 minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.

Cold Vapor Atomic Absorption (CVAA) - mercury measurements are conducted using SnC14 as the reducing agent. A Leeman PS200 Mercury Analyzer is employed for the analysis.

Method Codes: 001, 004, and 039 for silver.
Laboratory: Research Triangle Institute

Homogenization (001) - Soil/sediment samples are pre-homogenized using a food processor. A portion of the sample is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.

Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement (004) - Using a CEM microwave oven, 0.25 to 0.5 grams of freeze dried sample are heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and 15 minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.

ICP-MS (039) - sample is measured by ICP-MS.

Method Code:	Modification of EPA Method 314.0 for perchlorate
Laboratory:	Institute of Environmental and Human Health, Texas Tech University

Soil/sediment samples were analyzed by ion chromatography using a modification of EPA Method 314.0 because at the time this study was conducted, the USEPA had not established a method for analyzing soil matrices fro perchlorate.

APPENDIX B
(ANALYTICAL RESULTS)

Table 1. Moisture, sand, silt, and clay content as percentages measured in soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002.

Sample Site	% Moisture	% Sand	% Silt	% Clay
1	24.5	50.5	47.1	2.5
2	2.7	36.7	58.0	5.3
3	23.1	35.1	44.0	20.9
4	16.6	35.1	41.6	23.3
5	23.3	38.6	48.5	12.9
6	23.4	51.0	45.7	3.3
7	20.7	28.5	57.3	14.2
8	14.3	64.8	32.6	2.6
9	25.0	58.0	35.8	6.2
10	20.6	46.8	38.5	14.8
11	17.1	56.2	42.5	1.3
12	13.9	66.8	29.7	3.4
13	12.1	60.8	36.2	3.0
14	28.0	32.4	63.8	3.8
15	19.0	43.1	53.6	3.3
16	17.9	43.1	54.6	2.3
17	14.0	50.6	45.2	4.2
18	13.3	53.1	44.7	2.2
19	17.8	42.9	49.5	7.6
20	13.8	42.2	47.2	10.6
21	16.8	40.3	51.8	7.9
22	15.1	36.9	51.0	12.2
23	9.6	58.2	36.4	5.4
24	12.7	64.9	28.3	6.8
25	29.6	17.6	39.8	42.5
26	18.3	36.2	44.4	19.4
27	15.8	30.7	24.8	44.6
28	14.8	63.6	33.0	3.4
29	24.8	18.5	55.4	26.1
30	8.9	44.7	51.3	4.0
31	12.1	67.2	23.6	9.15
32	14.2	52.2	42.3	5.5
33	12.6	80.6	13.9	5.6
34	14.4	40.6	37.5	21.8
35	3.7	92.3	1.4	6.3
36	19.3	56.2	37.5	6.4
37	4.4	92.0	1.9	6.1
38	3.9	58.1	37.9	4.0
39	3.7	37.8	37.2	25.0
40	10.5	62.4	32.2	5.4
41	16.5	11.2	52.1	36.7
42	14.6	2.2	39.6	58.2
43	35.6	17.1	54.1	28.8

Table 2. Results of metals and perchlorate analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Aluminum	2,340.00	3,493.00	4,916.00	5,727.00	5,332.00	5,549.00	3,560.00	2,831.00	4,363.00
dl	10.50	10.60	10.30	10.50	10.50	10.30	10.40	10.30	10.30
Arsenic	1.16	1.17	0.61	1.44	1.86	2.18	1.19	1.06	1.48
dl	0.52	0.53	0.52	0.53	0.53	0.52	0.52	0.52	0.51
Barium	76.20	276.00	46.40	54.70	64.10	46.70	62.30	26.00	87.90
dl	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Beryllium	0.18	0.83	0.23	0.14	0.30	0.28	0.28	bdl	0.31
dl	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Boron	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	2.10	2.12	2.07	2.10	2.10	2.06	2.09	2.06	2.05
Cadmium	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.11	0.11	0.10	0.11	0.11	0.10	0.10	0.10	0.10
Chromium	6.51	5.58	5.86	6.44	7.89	9.87	5.91	5.85	6.90
dl	0.52	0.53	0.52	0.53	0.53	0.52	0.52	0.52	0.51
Copper	1.69	3.25	2.74	2.43	1.82	2.01	2.25	1.15	3.13
dl	0.52	0.53	0.52	0.53	0.53	0.52	0.52	0.52	0.51
Iron	4,126.00	3,842.00	3,533.00	6,851.00	5,833.00	7,470.00	4,773.00	3,439.00	5,353.00
dl	10.50	10.60	10.30	10.50	10.50	10.30	10.40	10.30	10.30
Lead	12.20	13.10	11.90	13.10	16.40	39.30	9.94	8.04	9.08
dl	2.10	2.12	2.07	2.10	2.10	2.06	2.09	2.06	2.05
Magnesium	188.00	240.00	314.00	464.00	307.00	172.00	217.00	155.00	334.00
dl	10.50	10.60	10.30	10.50	10.50	10.30	10.40	10.30	10.30
Manganese	510.00	956.00	170.00	585.00	1,455.00	1,048.00	785.00	87.50	621.00
dl	1.05	1.06	1.03	1.05	1.05	1.03	1.04	1.03	1.03
Mercury	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.11	0.11	0.10	0.11	0.11	0.10	0.10	0.10	0.10
Molybdenum	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	1.05	1.06	1.03	1.05	1.05	1.03	1.04	1.03	1.03
Nickel	2.64	5.40	2.27	3.99	4.01	2.27	2.69	2.18	4.13
dl	1.05	1.06	1.03	1.05	1.05	1.03	1.04	1.03	1.03
Selenium	0.73	bdl	bdl	0.87	0.65	bdl	bdl	bdl	bdl
dl	0.52	0.53	0.52	0.53	0.53	0.52	0.52	0.52	0.51
Silver	0.12	0.12	0.16	0.12	0.15	0.14	0.14	bdl	0.17
dl	0.11	0.11	0.10	0.11	0.11	0.10	0.10	0.10	0.10
Strontium	6.71	13.80	11.20	9.78	9.55	3.05	4.33	2.75	13.90
dl	0.52	0.53	0.52	0.53	0.53	0.52	0.52	0.52	0.51
Vanadium	10.60	11.50	10.80	14.20	18.80	23.60	15.30	10.10	13.70
dl	0.52	0.53	0.52	0.53	0.53	0.52	0.52	0.52	0.51
Zinc	8.70	13.50	9.34	26.80	16.70	9.33	7.67	5.29	10.70
dl	5.24	5.31	5.17	5.25	5.25	5.15	5.22	5.15	5.13
Perchlorate*	269.00	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	2.23	2.22	2.05	2.24	2.17	2.23	2.27	2.31	2.40

*Perchlorate analytical results are presented as µg/kg.

Table 2 (continued). Results of metals and perchlorate analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
Aluminum	5,154.00	2,350.00	2,075.00	3,395.00	7,909.00	2,868.00	2,385.00	2,848.00	2,363.00
dl	10.50	10.50	10.20	10.40	10.30	10.30	10.20	10.50	10.30
Arsenic	1.35	1.36	0.86	4.39	1.57	1.33	0.96	1.20	1.54
dl	0.53	0.52	0.51	0.52	0.52	0.52	0.51	0.53	0.51
Barium	71.90	137.00	39.10	64.30	80.00	64.30	55.00	103.00	105.00
dl	0.21	0.21	0.20	0.21	0.21	0.21	0.20	0.21	0.21
Beryllium	0.32	0.41	0.09	0.28	0.31	0.38	0.19	0.42	0.23
dl	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Boron	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	2.11	2.10	2.04	2.07	2.07	2.07	2.04	2.11	2.06
Cadmium	bdl	0.16	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.11	0.10
Chromium	7.19	8.26	8.95	17.30	13.40	6.57	5.24	9.05	3.91
dl	0.53	0.52	0.52	0.52	0.52	0.52	0.51	0.53	0.51
Copper	2.28	2.43	1.26	1.72	3.98	2.54	1.09	2.04	2.11
dl	0.53	0.52	0.51	0.52	0.52	0.52	0.51	0.53	0.51
Iron	6,172.00	4,358.00	3,943.00	16,442.00	7,441.00	4,587.00	2,814.00	4,128.00	3,180.00
dl	1050	1050	10.20	10.40	10.30	10.30	10.20	10.50	10.30
Lead	16.60	9.45	20.40	8.04	12.90	7.96	9.34	7.22	10.10
dl	2.11	2.10	2.04	2.07	2.07	2.07	2.04	2.11	2.06
Magnesium	281.00	168.00	116.00	165.00	380.00	193.00	136.00	159.00	208.00
dl	10.50	10.50	10.20	10.40	10.30	10.30	10.20	10.50	10.30
Manganese	169.00	903.00	286.00	994.00	357.00	589.00	320.00	657.00	680.00
dl	1.05	1.05	1.02	1.04	1.03	1.03	1.02	1.05	1.03
Mercury	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.11	0.10
Molybdenum	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	1.05	1.05	1.02	1.04	1.03	1.03	1.02	1.05	1.03
Nickel	3.05	6.55	2.53	4.24	7.28	3.81	2.02	3.47	3.48
dl	1.05	1.05	1.02	1.04	1.03	1.03	1.02	1.05	1.03
Selenium	bdl	bdl	bdl	0.62	bdl	bdl	bdl	bdl	bdl
dl	0.53	0.52	0.51	0.52	0.52	0.52	0.51	0.53	0.51
Silver	0.15	0.13	bdl	bdl	0.14	0.12	0.11	0.12	0.12
dl	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.11	0.10
Strontium	3.90	13.40	3.29	5.42	10.80	5.10	4.06	3.89	14.60
dl	0.53	0.52	0.51	0.52	0.52	0.52	0.51	0.53	0.51
Vanadium	17.20	10.90	9.87	30.70	19.00	12.00	8.32	11.20	8.99
dl	0.53	0.52	0.51	0.52	0.52	0.52	0.51	0.53	0.51
Zinc	9.22	11.40	7.85	8.40	16.70	7.58	bdl	5.56	9.10
dl	5.27	5.24	5.10	5.19	5.17	5.17	5.09	5.26	5.14
Perchlorate*	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	2.30	2.32	2.15	2.09	2.11	2.12	2.23	2.24	2.25

*Perchlorate analytical results are presented as μg/kg.

Table 2 (continued). Results of metals and perchlorate analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27
Aluminum	7,940.00	7,416.00	3,304.00	4,132.00	1,635.00	3,233.00	13,090.00	5,464.00	18,160.00
dl	10.20	10.20	1.02	1.01	1.00	1.01	1.03	1.01	1.00
Arsenic	7.38	8.40	3.06	2.44	1.14	2.43	2.80	2.33	4.96
dl	0.51	0.51	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Barium	82.30	65.60	63.90	48.30	21.20	26.50	90.60	48.60	45.00
dl	0.21	0.20	1.02	1.01	1.00	1.01	1.03	1.01	1.00
Beryllium	0.24	0.26	0.52	0.33	0.17	0.27	0.43	0.28	0.51
dl	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Boron	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	2.05	2.04	1.02	1.01	1.00	1.01	1.03	1.01	1.00
Cadmium	bdl	bdl	bdl	bdl	0.29	bdl	0.20	0.35	0.45
dl	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Chromium	23.20	12.10	9.80	9.66	7.91	12.60	15.80	9.94	25.10
dl	0.51	0.51	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Copper	8.26	6.67	2.22	3.12	0.99	1.85	5.96	3.94	11.60
dl	0.51	0.51	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Iron	28,100.00	10,704.00	5,710.00	8,038.00	5,101.00	7,607.00	11,610.00	10,270.00	27,190.00
dl	40.20	10.20	5.08	5.06	5.00	5.07	5.13	5.06	5.01
Lead	53.90	78.20	9.68	11.50	6.86	10.60	63.40	15.40	10.0
dl	2.05	2.04	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Magnesium	311.00	411.00	154.00	191.00	104.00	170.00	966.00	526.00	1,033.00
dl	10.20	10.20	5.08	5.06	5.00	5.07	5.13	5.06	5.01
Manganese	532.00	56.50	508.00	127.00	308.00	196.00	98.90	586.00	26.50
dl	1.02	1.02	1.02	1.01	1.00	1.01	1.03	1.01	1.00
Mercury	bdl	bdl	bdl	0.06	bdl	bdl	0.17	0.26	0.15
dl	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Molybdenum	bdl	bdl	0.53	bdl	bdl	bdl	0.57	bdl	bdl
dl	1.02	1.02	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Nickel	6.76	5.08	3.29	2.56	1.91	2.49	5.18	5.52	10.20
dl	1.02	1.02	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Selenium	bdl	0.57	bdl	bdl	bdl	8.57	bdl	bdl	0.59
dl	0.51	0.51	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Silver	0.28	0.15	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.10	0.10	0.20	0.20	0.20	0.20	0.21	0.20	0.20
Strontium	12.10	7.35	4.22	3.91	1.79	3.89	25.60	11.80	13.20
dl	0.51	0.51	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Vanadium	43.50	19.90	12.40	19.70	8.64	15.60	21.50	17.50	39.00
dl	0.51	0.51	0.51	0.51	0.50	0.51	0.51	0.51	0.50
Zinc	70.50	33.80	6.62	5.90	4.08	5.10	42.20	17.50	32.30
dl	5.12	5.11	1.02	1.01	1.00	1.01	1.03	1.01	1.00
Perchlorate*	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	2.38	2.19	1.91	1.98	1.91	1.73	1.95	1.97	1.87

*Perchlorate analytical results are presented as μg/kg.

Table 2 (continued). Results of metals and perchlorate analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 28	Site 29	Site 30	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
Aluminum	1,868.00	12,620.00	1,401.00	2,398.00	1,791.00	1,058.00	4,948.00	889.00	2,305.00
dl	1.03	1.02	1.00	1.00	1.01	1.01	1.01	1.03	1.03
Arsenic	0.93	3.42	1.61	0.71	2.20	1.07	2.45	0.55	2.48
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Barium	21.40	214.00	53.90	48.50	16.90	27.10	55.80	9.35	59.80
dl	1.03	1.02	1.00	1.00	1.01	1.01	1.01	1.03	1.03
Beryllium	0.18	0.79	0.21	0.18	0.24	0.13	0.35	0.05	0.33
dl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Boron	bdl	bdl	bdl	bdl	bdl	1.06	bdl	bdl	bdl
dl	1.03	1.02	1.00	1.00	1.01	1.01	1.01	1.03	1.03
Cadmium	bdl	0.71	0.13	bdl	0.12	0.10	0.30	bdl	0.21
dl	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Chromium	6.43	19.20	6.08	5.17	11.20	4.18	10.80	3.22	8.75
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Copper	0.95	13.80	1.44	1.81	1.37	1.15	4.44	1.18	2.39
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Iron	2,985.00	24,420.00	3,050.00	2,812.00	7,130.00	1,836.00	12,340.00	2,414.00	7,621.00
dl	5.15	5.08	5.01	5.00	5.03	5.03	5.03	5.13	5.13
Lead	9.24	51.90	11.70	7.84	7.52	11.60	10.90	1.52	11.60
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Magnesium	142.00	3,163.00	130.00	196.00	126.00	104.00	550.00	79.70	273.00
dl	5.15	5.08	5.01	5.00	5.03	5.03	5.03	5.13	5.13
Manganese	183.00	1,171.00	441.00	270.00	123.00	70.20	262.00	12.60	356.00
dl	1.03	1.02	1.00	1.00	1.01	1.01	1.01	1.03	1.03
Mercury	bdl	0.12	bdl	0.06	bdl	bdl	bdl	bdl	bdl
dl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Molybdenum	bdl	bdl	bdl	bdl	bdl	0.54	bdl	bdl	bdl
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Nickel	1.71	28.30	1.69	2.26	1.80	1.10	6.00	bdl	4.03
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Selenium	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Silver	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.21	0.21
Strontium	4.52	63.20	3.01	10.90	3.18	6.44	8.88	2.20	13.10
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Vanadium	7.19	23.30	11.00	6.82	14.20	4.57	20.00	5.99	11.40
dl	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Zinc	5.63	92.40	3.84	7.99	4.26	3.95	19.70	2.02	12.10
dl	1.03	1.02	1.00	1.00	1.01	1.01	1.01	1.03	1.03
Perchlorate*	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	2.04	2.00	1.83	1.87	1.92	1.68	1.74	2.03	1.77

*Perchlorate analytical results are presented as μg/kg.

Table 2 (continued). Results of metals and perchlorate analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42	Site 43
Aluminum	1,679.00	1,740.00	9,280.00	1,869.00	7,279.00	6,586.00	3,488.00
dl	1.03	1.01	1.01	1.03	1.01	1.04	1.02
Arsenic	0.66	0.67	4.04	0.90	3.20	6.69	2.35
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Barium	24.10	47.60	78.10	39.20	61.80	149.00	69.50
dl	1.03	1.01	14.01	1.03	1.01	1.04	1.02
Beryllium	0.14	0.32	0.57	0.31	0.53	0.69	0.96
dl	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Boron	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	1.03	1.01	1.01	1.03	1.01	1.04	1.02
Cadmium	0.16	0.15	0.64	0.17	0.47	0.35	0.47
dl	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Chromium	5.54	7.51	12.00	6.30	14.70	9.30	16.60
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Copper	1.17	2.22	15.00	1.43	5.11	7.86	6.90
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Iron	3,509.00	5,624.00	17,630.00	3,864.00	14,380.00	17,860.00	11,160.00
dl	5.15	5.06	5.04	5.13	5.03	5.18	5.11
Lead	2.83	5.96	15.90	8.25	12.50	13.30	11.20
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Magnesium	111.00	121.00	3,306.00	124.00	516.00	1,274.00	246.00
dl	5.15	5.06	5.04	5.13	5.03	5.18	5.11
Manganese	40.10	257.00	195.00	125.00	53.30	142.00	222.00
dl	1.03	1.01	1.01	1.03	1.01	1.04	1.02
Mercury	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Molybdenum	bdl	bdl	bdl	bdl	bdl	0.52	bdl
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Nickel	0.96	3.46	25.80	1.71	4.78	7.44	5.71
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Selenium	bdl	bdl	bdl	bdl	bdl	0.67	bdl
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Silver	bdl	1.16	bdl	bdl	bdl	bdl	bdl
dl	0.21	0.20	0.20	0.21	0.20	0.21	0.20
Strontium	2.24	3.32	24.00	4.23	9.04	32.90	10.20
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Vanadium	7.87	8.55	20.40	8.18	30.50	22.10	34.20
dl	0.52	0.51	0.50	0.51	0.50	0.52	0.51
Zinc	2.66	6.42	86.40	5.08	17.30	40.80	24.20
dl	1.03	1.01	1.01	1.03	1.01	1.04	1.02
Perchlorate*	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	1.91	1.97	1.83	1.79	1.89	1.87	1.74

*Perchlorate analytical results are presented as µg/kg.

Table 3. Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
1,2,4-trichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
1,2-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
1,3-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
1,4-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
1-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
1-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,3,4,6-tetrachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,4,5-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,4,6-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,4-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,4-dimethylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,4-dinitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,4-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,6-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2,6-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-chlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-picoline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
2-methylnaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
3,3'-dichlorobenzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
3-methylcholanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
3-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4,6-dinitro-2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4-aminobiphenyl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; bdl is below the analytical detection limit; and ★ denotes detected above the analytical detection limit).

Analyte	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
1,2,4-trichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
1,2-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
1,3-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
1,4-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
1-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
1-naphthylamine★	bdl	bdl	bdl	bdl	0.236	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,3,4,6-tetrachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,4,5-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,4,6-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,4-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,4-dimethylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,4-dinitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,4-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,6-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2,6-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-chlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-nitroaniline★	bdl	bdl	bdl	bdl	0.542	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-picoline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
2-methylnaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
3,3'-dichlorobenzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
3-methylcholanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
3-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4,6-dinitro-2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4-aminobiphenyl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27
1,2,4-trichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
1,2-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
1,3-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
1,4-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
1-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
1-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,3,4,6-tetrachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,4,5-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,4,6-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,4-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,4-dimethylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,4-dinitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,4-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,6-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2,6-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-chlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-picoline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
2-methylnaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
3,3'-dichlorobenzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
3-methylcholanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
3-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4,6-dinitro-2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4-aminobiphenyl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 28	Site 29	Site 30	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
1,2,4-trichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
1,2-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
1,3-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
1,4-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
1-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
1-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,3,4,6-tetrachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,4,5-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,4,6-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,4-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,4-dimethylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,4-dinitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,4-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,6-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2,6-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-chlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-picoline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
2-methylnaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
3,3'-dichlorobenzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
3-methylcholanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
3-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4,6-dinitro-2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4-aminobiphenyl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42	Site 43
1,2,4-trichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
1,2-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
1,3-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
1,4-dichlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
1-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
1-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,3,4,6-tetrachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,4,5-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,4,6-trichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,4-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,4-dimethylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,4-dinitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,4-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,6-dichlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2,6-dinitrotoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-chloronaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-chlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-naphthylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-picoline	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
2-methylnaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
3,3'-dichlorobenzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
3-methylcholanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
3-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4,6-dinitro-2-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4-aminobiphenyl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
4-bromophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4-chloro-3-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4-chloroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4-chlorophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
4-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
7,12-dimethylbenz(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
acentophenone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
aniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzo(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzoic acid	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzyl alcohol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
bis(2-chloroethoxy)methane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
bis(2-chloroethyl)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
bis(2-ethylhexyl)phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
bis(2chloroisopropy)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
butylbenzylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
carbazole	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
di-n-butylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
di-n-octylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
dibenz(a,h)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
dibenz(a,j)acridine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
dibenzofuran	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
diethyl phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
dimethylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
diphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
4-bromophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4-chloro-3-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4-chloroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4-chlorophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
4-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
7,12-dimethylbenz(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
acentophenone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
aniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzo(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzoic acid	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzyl alcohol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
bis(2-chloroethoxy)methane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
bis(2-chloroethyl)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
bis(2-ethylhexyl)phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
bis(2chloroisopropy)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
butylbenzylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
carbazole	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
di-n-butylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
di-n-octylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
dibenz(a,h)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
dibenz(a,j)acridine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
dibenzofuran	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
diethyl phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
dimethylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
diphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27
4-bromophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4-chloro-3-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4-chloroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4-chlorophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
4-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
7,12-dimethylbenz(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
acentophenone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
aniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzo(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzoic acid	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzyl alcohol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
bis(2-chloroethoxy)methane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
bis(2-chloroethyl)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
bis(2-ethylhexyl)phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
bis(2chloroisopropy)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
butylbenzylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
carbazole	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
di-n-butylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
di-n-octylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
dibenz(a,h)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
dibenz(a,j)acridine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
dibenzofuran	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
diethyl phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
dimethylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
diphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 28	Site 29	Site 30	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
4-bromophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4-chloro-3-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4-chloroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4-chlorophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
4-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
7,12-dimethylbenz(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
acentophenone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
aniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzo(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzoic acid	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzyl alcohol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
bis(2-chloroethoxy)methane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
bis(2-chloroethyl)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
bis(2-ethylhexyl)phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
bis(2chloroisopropy)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
butylbenzylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
carbazole	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
di-n-butylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
di-n-octylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
dibenz(a,h)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
dibenz(a,j)acridine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
dibenzofuran	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
diethyl phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
dimethylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
diphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42	Site 43
4-bromophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4-chloro-3-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4-chloroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4-chlorophenyl-phenylether	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4-methylphenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4-nitroaniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
4-nitrophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
7,12-dimethylbenz(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
acentophenone	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
aniline	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzo(a)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzoic acid	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzyl alcohol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
bis(2-chloroethoxy)methane	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
bis(2-chloroethyl)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
bis(2-ethylhexyl)phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
bis(2chloroisopropy)ether	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
butylbenzylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
carbazole	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
di-n-butylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
di-n-octylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
dibenz(a,h)anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
dibenz(a,j)acridine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
dibenzofuran	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
diethyl phthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
dimethylphthalate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
diphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
ethyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
hexachlorobutadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
hexachlorocyclopentadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
hexachloroethane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
isophorone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
methyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
n-nitroso-di-n-propylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
n-nitrosopiperidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
nitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
pentachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
pentachloronitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
pentachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
phenacetin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
phenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
pronamide	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
a,a-dimethylphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
acenaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
acenaphthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzo(a)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzo(b)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzo(g,h,i)perylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
benzo(k)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
chrysene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
fluorene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
indeno(1,2,3-cd)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
n-nitrosodiphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
ethyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
hexachlorobutadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
hexachlorocyclopentadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
hexachloroethane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
isophorone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
methyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
n-nitroso-di-n-propylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
n-nitrosopiperidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
nitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
pentachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
pentachloronitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
pentachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
phenacetin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
phenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
pronamide	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
a,a-dimethylphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
acenaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0188
acenaphthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzo(a)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzo(b)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzo(g,h,i)perylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
benzo(k)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
chrysene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
fluorene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
indeno(1,2,3-cd)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
n-nitrosodiphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27
ethyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
hexachlorobutadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
hexachlorocyclopentadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
hexachloroethane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
isophorone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
methyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
n-nitroso-di-n-propylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
n-nitrosopiperidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
nitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
pentachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
pentachloronitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
pentachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
phenacetin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
phenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
pronamide	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
a,a-dimethylphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
acenaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
acenaphthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzo(a)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzo(b)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzo(g,h,i)perylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
benzo(k)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
chrysene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
fluorene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
indeno(1,2,3-cd)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
n-nitrosodiphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 28	Site 29	Site 30	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
ethyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
hexachlorobutadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
hexachlorocyclopentadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
hexachloroethane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
isophorone	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
methyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
n-nitroso-di-n-propylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
n-nitrosopiperidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
nitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
pentachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
pentachloronitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
pentachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
phenacetin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
phenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
pronamide	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
a,a-dimethylphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
acenaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
acenaphthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzo(a)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzo(b)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzo(g,h,i)perylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
benzo(k)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
chrysene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
fluorene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
indeno(1,2,3-cd)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
n-nitrosodiphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42	Site 43
ethyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
hexachlorobutadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
hexachlorocyclopentadiene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
hexachloroethane	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
isophorone	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
methyl methanesulfonate	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
n-nitroso-di-n-propylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
n-nitrosopiperidine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
nitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
pentachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
pentachloronitrobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
pentachlorophenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
phenacetin	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
phenol	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
pronamide	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
a,a-dimethylphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
acenaphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
acenaphthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
anthracene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzo(a)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzo(b)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzo(g,h,i)perylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
benzo(k)fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
chrysene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
fluoranthene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
fluorene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
indeno(1,2,3-cd)pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
n-nitrosodiphenylamine	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
naphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
p-dimethylaminoazobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
phenanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221
pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.223	0.218	0.216	0.199	0.217	0.217	0.211	0.194	0.221

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
naphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
p-dimethylaminoazobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
phenanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188
pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.209	0.201	0.192	0.189	0.229	0.204	0.202	0.192	0.188

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27
naphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
p-dimethylaminoazobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
phenanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293
pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.202	0.183	0.300	0.292	0.274	0.285	0.352	0.302	0.293

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 28	Site 29	Site 30	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
naphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
p-dimethylaminoazobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
phenanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306
pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.290	0.328	0.271	0.280	0.290	0.285	0.289	0.258	0.306

Table 3 (continued). Results of semi-volatile analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42	Site 43
naphthalene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
p-dimethylaminoazobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
phenanthrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383
pyrene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.259	0.258	0.258	0.276	0.295	0.291	0.383

Table 4. Results of organochlorine pesticide and total PCB analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
1,2,3,4-tetrachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
1,2,4,5-tetrachlorobenzene★	0.0012	0.000377	0.000309	0.000507	0.000189	bdl	bdl	0.000394	0.000234
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
aldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
HCB★	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.000198
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
heptachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
total PCB★	0.00768	0.00759	0.0123	0.0246	0.00457	0.00477	0.00467	0.00386	0.0142
dl	0.00164	0.00160	0.00162	0.00150	0.00162	0.00156	0.00157	0.00142	0.00169
αBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
αchlordane★	bdl	bdl	bdl	0.00182	bdl	bdl	bdl	bdl	0.000744
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
βBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
cis-nonachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
δBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
dieldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
endosulfan II	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
endrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
γBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
γchlordane★	bdl	bdl	bdl	0.000462	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
heptachlor epoxide	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
mirex	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
o,p'-DDD★	bdl	bdl	bdl	0.000414	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
o,p'-DDE	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
o,p'-DDT★	bdl	bdl	bdl	0.000228	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
oxychlordane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
p,p'-DDD	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
p,p'-DDE★	0.000662	0.000718	0.000209	0.0107	bdl	bdl	bdl	0.000251	0.00496
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
p,p'-DDT	bdl	bdl	bdl	0.000306	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
pentachloro-anisole★	0.000572	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.000181
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169
toxaphene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.00164	0.00160	0.00162	0.00150	0.00162	0.00156	0.00157	0.00142	0.00169
trans-nonachlor★	bdl	bdl	bdl	0.000152	bdl	bdl	bdl	bdl	bdl
dl	0.000164	0.000160	0.000162	0.000150	0.000162	0.000156	0.000157	0.000142	0.000169

★Denotes detected above the analytical detection limit.

Table 4 (continued). Results of organochlorine pesticide and total PCB analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
1,2,3,4-tetrachlorobenzene★	bdl	bdl	bdl	bdl	0.000204	bdl	0.000204	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
1,2,4,5-tetrachlorobenzene★	0.000162	0.000306	0.00231	0.000204	0.000607	0.000894	0.000560	0.000519	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
aldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
HCB★	bdl	0.000163	bdl	bdl	bdl	0.000160	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
heptachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
total PCB★	0.0109	0.0107	0.0136	0.0231	0.0651	0.0278	0.0125	0.00665	0.0166
dl	0.00154	0.00150	0.00145	0.00141	0.00166	0.00160	0.00152	0.00148	0.00142
αBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
αchlordane★	bdl	bdl	bdl	0.000180	0.00351	0.00181	0.000215	bdl	0.000756
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
βBHC★	bdl	bdl	bdl	bdl	0.000641	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
cis-nonachlor★	bdl	bdl	bdl	bdl	0.00258	0.000867	bdl	bdl	0.000282
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
δBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
dieldrin★	bdl	bdl	0.000239	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
endosulfan II★	0.000164	bdl	bdl	0.000239	0.00157	0.000695	0.000178	bdl	0.000638
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
endrin★	bdl	bdl	bdl	bdl	0.000236	0.000231	bdl	bdl	0.000149
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
γBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
γchlordane★	bdl	bdl	bdl	bdl	0.000827	0.000415	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
heptachlor epoxide★	bdl	bdl	bdl	bdl	0.000199	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
mirex	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
o,p'-DDD★	0.000387	0.000238	0.000418	0.000331	0.000874	0.000704	0.000324	0.000353	0.000347
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
o,p'-DDE★	bdl	bdl	0.000219	bdl	0.000428	0.000435	0.000411	bdl	0.000194
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
o,p'-DDT★	bdl	bdl	0.000157	0.000144	0.000616	0.000307	bdl	bdl	0.000264
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
oxychlordane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
p,p'-DDD★	bdl	bdl	bdl	bdl	0.00323	0.000948	bdl	bdl	0.000290
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
p,p'-DDE★	0.000364	0.000194	0.000645	0.000503	0.0320	0.0106	0.00159	bdl	0.00213
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
p,p'-DDT★	0.000188	bdl	0.000324	0.000230	0.000589	bdl	0.000191	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
pentachloro-anisole★	bdl	bdl	0.000495	0.00925	bdl	0.000324	0.000186	bdl	0.000192
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142
toxaphene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.00154	0.00150	0.00145	0.00141	0.00166	0.00160	0.00152	0.00148	0.00142
trans-nonachlor★	bdl	bdl	bdl	bdl	0.000424	bdl	bdl	bdl	bdl
dl	0.000154	0.000150	0.000145	0.000141	0.000166	0.000160	0.000152	0.000148	0.000142

★Denotes detected above the analytical detection limit.

Table 4 (continued). Results of organochlorine pesticide and total PCB analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27
1,2,3,4-tetrachlorobenzene★	0.000166	0.000187	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
1,2,4,5-tetrachlorobenzene★	0.000539	0.000743	0.00203	0.00203	0.00166	0.00213	0.00241	0.00293	0.00194
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
aldrin★	bdl	bdl	bdl	bdl	bdl	bdl	0.000412	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
HCB★	0.000389	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
heptachlor★	0.000195	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
total PCB★	0.100	0.0568	0.0127	0.00625	0.00653	0.00997	0.633	0.0200	0.00356
dl	0.00161	0.00145	0.00148	0.00147	0.00137	0.00142	0.00174	0.00153	0.00146
αBHC★	0.000188	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
αchlordane★	0.0132	0.000570	bdl	bdl	bdl	bdl	0.00184	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
βBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
cis-nonachlor★	0.0115	0.00168	bdl	bdl	bdl	bdl	0.00338	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
δBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
dieldrin★	0.000373	bdl	bdl	bdl	bdl	bdl	0.00111	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
endosulfan II★	0.000505	0.000447	bdl	bdl	bdl	bdl	0.00695	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
endrin★	0.000213	0.000240	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
γBHC★	0.000223	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
γchlordane★	0.0124	0.000258	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
heptachlor epoxide★	0.00131	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
mirex★	bdl	0.000503	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
o,p'-DDD★	0.00461	0.00173	0.000725	0.00105	0.000681	0.000822	0.00645	0.000856	0.000886
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
o,p'-DDE★	0.00174	0.00108	bdl	bdl	bdl	bdl	0.00132	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
o,p'-DDT★	0.0104	0.00490	bdl	0.000439	bdl	bdl	0.00366	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
oxychlordane★	0.00346	0.000429	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
p,p'-DDD★	0.0104	0.00474	bdl	0.000421	bdl	bdl	0.00674	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
p,p'-DDE★	0.151	0.190	0.000375	0.00217	0.00107	0.000301	0.311	0.000450	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
p,p'-DDT★	0.0395	0.0422	bdl	0.00195	bdl	bdl	0.0154	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
pentachloro-anisole★	0.000193	0.000163	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293
toxaphene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.00161	0.00145	0.00148	0.00147	0.00137	0.00142	0.00174	0.00153	0.00146
trans-nonachlor★	0.0272	0.00370	bdl	bdl	bdl	bdl	0.00103	bdl	bdl
dl	0.000161	0.000145	0.000295	0.000295	0.000273	0.000284	0.000348	0.000305	0.000293

★Denotes detected above the analytical detection limit.

Table 4 (continued). Results of organochlorine pesticide and total PCB analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 28	Site 29	Site 30	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
1,2,3,4-tetrachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
1,2,4,5-tetrachlorobenzene★	0.00277	0.00309	bdl	0.00223	bdl	0.000388	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
aldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
HCB	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
heptachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
total PCB★	0.0113	0.0275	0.00417	0.0141	0.0559	0.0126	0.0249	0.00176	0.0803
dl	0.00145	0.00165	0.00135	0.00141	0.00145	0.00143	0.00145	0.00130	0.00154
αBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
αchlordane	bdl	0.00113	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
βBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
cis-nonachlor	bdl	0.000814	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
δBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
dieldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
endosulfan II★	bdl	0.000705	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
endrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
γBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
γchlordane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
heptachlor epoxide	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
mirex	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
o,p'-DDD★	0.000946	0.00130	bdl	0.000795	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
o,p'-DDE	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
o,p'-DDT★	bdl	0.000343	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
oxychlordane	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
p,p'-DDD★	bdl	0.000400	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
p,p'-DDE★	0.000897	0.00546	0.000483	0.00274	0.00136	0.00104	0.000383	bdl	0.000877
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
p,p'-DDT★	bdl	0.000467	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
pentachloro-anisole★	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.00487
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308
toxaphene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.00145	0.00165	0.00135	0.00141	0.00145	0.00143	0.00145	0.00130	0.00154
trans-nonachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000291	0.000330	0.000270	0.000283	0.000289	0.000286	0.000290	0.000260	0.000308

★Denotes detected above the analytical detection limit.

Table 4 (continued). Results of organochlorine pesticide and total PCB analyses in mg/kg dry weight for soil/sediment samples collected from 43 sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42	Site 43
1,2,3,4-tetrachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
1,2,4,5-tetrachlorobenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
aldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
HCB	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
heptachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
total PCB	0.00146	0.00812	0.00904	0.00648	0.00803	0.0119	0.0214
dl	0.00129	0.00129	0.00129	0.00139	0.00147	0.00145	0.00192
αBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
αchlordane★	bdl	bdl	bdl	0.000469	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
βBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
cis-nonachlor★	bdl	bdl	bdl	0.000666	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
δBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
dieldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
endosulfan II	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
endrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
γBHC	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
γchlordane★	bdl	bdl	bdl	bdl	bdl	bdl	0.000423
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
heptachlor epoxide	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
mirex	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
o,p'-DDD★	bdl	bdl	bdl	bdl	bdl	bdl	0.0186
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
o,p'-DDE★	bdl	bdl	bdl	bdl	bdl	bdl	0.00201
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
o,p'-DDT★	bdl	bdl	bdl	bdl	bdl	bdl	0.000718
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
oxychlordane	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
p,p'-DDD★	bdl	bdl	bdl	bdl	bdl	bdl	0.0628
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
p,p'-DDE★	bdl	bdl	0.000915	0.00404	bdl	0.00192	0.0401
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
p,p'-DDT★	bdl	bdl	bdl	bdl	bdl	bdl	0.0637
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
pentachloro-anisole★	bdl	bdl	0.00165	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384
toxaphene	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.00129	0.00129	0.00129	0.00139	0.00147	0.00145	0.00192
trans-nonachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl
dl	0.000259	0.000258	0.000257	0.000279	0.000295	0.000290	0.000384

★Denotes detected above the analytical detection limit.

Table 5. Results of dioxins/furans analyses in mg/kg dry weight for soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; bdl is below the analytical detection limit; and TEQ is calculated toxic equivalency value).

Analyte	Site 5	Site 10	Site 22	Site 31	Site 42
TCDD	bdl	bdl	bdl	bdl	bdl
dl	0.00000028	0.00000025	0.00000027	0.00000022	0.00000028
PeCDD	bdl	bdl	bdl	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,4,7,8-HxCDD	bdl	bdl	bdl	bdl	0.00000340
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,6,7,8-HxCDD	bdl	bdl	bdl	bdl	0.0000103
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,7,8,9-HxCDD	bdl	bdl	bdl	bdl	0.000016
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
HpCDD	0.00000640	0.00001120	bdl	0.000029	0.000242
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
OCDD	0.00019800	0.00036500	0.000121	0.00203	0.00355
dl	0.00000283	0.00000249	0.00000268	0.00000225	0.00000283
TCDF	bdl	bdl	bdl	bdl	bdl
dl	0.00000028	0.00000025	0.00000027	0.00000022	0.00000028
1,2,3,7,8-PeCDF	bdl	bdl	bdl	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
2,3,4,7,8-PeCDF	bdl	bdl	bdl	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,4,7,8-HxCDF	bdl	bdl	bdl	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,6,7,8-HxCDF	bdl	bdl	bdl	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,7,8,9-HxCDF	bdl	bdl	bdl	bdl	0.00000293
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
2,3,4,6,7,8-HxCDF	bdl	bdl	bdl	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,4,6,7,8-HpCDF	bdl	bdl	0.00000271	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
1,2,3,4,7,8,9-HpCDF	bdl	bdl	bdl	bdl	bdl
dl	0.00000141	0.00000125	0.00000134	0.00000112	0.00000142
OCDF	bdl	bdl	0.00000330	bdl	bdl
dl	0.00000283	0.00000249	0.00000268	0.00000225	0.00000283
TEQ	0.00000010	0.00000040	0.00000010	0.00000220	0.0000091

APPENDIX C
(FIELD DUPLICATES ANALYTICAL RESULTS)

Moisture, sand, silt, and clay content as percentages measured in field duplicate (DUP) soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002.

Sample Site	% Moisture	% Sand	% Silt	% Clay
Site 5 DUP	25.5	37.7	50.0	12.3
Site 10 DUP	20.0	43.4	39.9	16.7
Site 22 DUP	19.4	34.8	51.1	14.2
Site 31 DUP	11.5	71.6	23.2	5.2
Site 42 DUP	13.3	3.0	40.9	56.2

Results of metals and perchlorate analyses in mg/kg dry weight for field duplicate soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 5 DUP	Site 10 DUP	Site 22 DUP	Site 31 DUP	Site 42 DUP
Aluminum	4,205.00	8,069.00	3,767.00	1,477.00	6,341.00
dl	10.30	10.50	1.03	1.02	1.01
Arsenic	1.62	2.23	1.36	0.79	8.35
dl	0.52	0.53	0.52	0.51	0.51
Barium	48.20	72.20	43.00	37.20	173.00
dl	0.21	0.21	1.03	1.02	1.01
Beryllium	0.29	0.36	0.24	0.14	0.78
dl	0.02	0.02	0.03	0.03	0.03
Boron	bdl	bdl	bdl	bdl	bdl
dl	2.07	2.11	1.03	1.02	1.01
Cadmium	bdl	bdl	bdl	bdl	0.56
dl	0.10	0.11	0.10	0.10	0.10
Chromium	6.53	11.80	12.80	3.95	11.70
dl	0.52	0.53	0.52	0.51	0.51
Copper	1.59	3.64	2.80	1.62	9.04
dl	0.52	0.53	0.52	0.51	0.51
Iron	5,607.00	9,458.00	5,100.00	2,634.00	19,630.00
dl	10.30	10.50	5.15	5.09	5.05
Lead	16.30	14.80	12.40	6.42	15.60
dl	2.07	2.11	0.52	0.51	0.51
Magnesium	234.00	366.00	200.00	141.00	1,373.00
dl	10.30	10.50	5.15	5.09	5.05
Manganese	893.00	203.00	87.20	217.00	86.80
dl	1.03	1.05	1.03	1.02	1.01
Mercury	bdl	bdl	0.21	bdl	bdl
dl	0.10	0.11	0.05	0.05	0.05
Molybdenum	bdl	bdl	bdl	bdl	bdl
dl	1.03	1.05	0.52	0.51	0.51
Nickel	2.44	4.76	2.17	1.48	8.44
dl	1.03	1.05	0.52	0.51	0.51
Selenium	bdl	0.57	bdl	bdl	0.52
dl	0.52	0.53	0.52	0.51	0.51
Silver	0.14	0.14	bdl	bdl	bdl
dl	0.10	0.10	0.21	0.20	0.20
Strontium	6.55	4.15	3.00	7.88	34.20
dl	0.52	0.53	0.52	0.51	0.51
Vanadium	17.80	21.90	18.40	5.71	27.90
dl	0.52	0.53	0.52	0.51	0.51
Zinc	8.86	13.30	5.90	5.78	43.50
dl	5.17	5.27	1.03	1.02	1.01
Perchlorate*	bdl	bdl	bdl	bdl	bdl
dl	2.13	2.49	2.03	1.87	1.91

*Perchlorate analytical results are presented as µg/kg.

Results of semi-volatile analyses in mg/kg dry weight for field duplicate (DUP) soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 5 DUP	Site 10 DUP	Site 22 DUP	Site 31 DUP	Site 42 DUP
1,2,4-trichlorobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
1,2-dichlorobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
1,3-dichlorobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
1,4-dichlorobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
1-chloronaphthalene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
1-naphthylamine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,3,4,6-tetrachlorophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,4,5-trichlorophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,4,6-trichlorophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,4-dichlorophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,4-dimethylphenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,4-dinitrophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,4-dinitrotoluene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,6-dichlorophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2,6-dinitrotoluene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-chloronaphthalene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-chlorophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-methylphenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-naphthylamine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-nitroaniline	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-nitrophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-picoline	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
2-methylnaphthalene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
3,3'-dichlorobenzidine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
3-methylcholanthrene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
3-nitroaniline	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4,6-dinitro-2-methylphenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4-aminobiphenyl	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285

Results of semi-volatile analyses in mg/kg dry weight for field duplicate (DUP) soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 5 DUP	Site 10 DUP	Site 22 DUP	Site 31 DUP	Site 42 DUP
4-bromophenyl-phenylether	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4-chloro-3-methylphenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4-chloroaniline	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4-chlorophenyl-phenylether	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4-methylphenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4-nitroaniline	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
4-nitrophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
7,12-dimethylbenz(a)anthracene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
acentophenone	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
aniline	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzidine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzo(a)anthracene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzoic acid	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzyl alcohol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
bis(2-chloroethoxy)methane	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
bis(2-chloroethyl)ether	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
bis(2-ethylhexyl)phthalate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
bis(2chloroisopropy)ether	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
butylbenzylphthalate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
carbazole	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
di-n-butylphthalate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
di-n-octylphthalate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
dibenz(a,h)anthracene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
dibenz(a,j)acridine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
dibenzofuran	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
diethyl phthalate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
dimethylphthalate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
diphenylamine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285

Results of semi-volatile analyses in mg/kg dry weight for field duplicate (DUP) soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 5 DUP	Site 10 DUP	Site 22 DUP	Site 31 DUP	Site 42 DUP
ethyl methanesulfonate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
hexachlorobutadiene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
hexachlorocyclopentadiene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
hexachloroethane	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
isophorone	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
methyl methanesulfonate	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
n-nitroso-di-n-propylamine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
n-nitrosopiperidine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
nitrobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
pentachlorobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
pentachloronitrobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
pentachlorophenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
phenacetin	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
phenol	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
pronamide	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
a,a-dimethylphenylamine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
acenaphthalene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
acenaphthene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
anthracene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzo(a)pyrene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzo(b)fluoranthene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzo(g,h,i)perylene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
benzo(k)fluoranthene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
chrysene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
fluoranthene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
fluorene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
indeno(1,2,3-cd)pyrene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
n-nitrosodiphenylamine	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285

Results of semi-volatile analyses in mg/kg dry weight for field duplicate (DUP) soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit).

Analyte	Site 5 DUP	Site 10 DUP	Site 22 DUP	Site 31 DUP	Site 42 DUP
naphthalene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
p-dimethylaminoazobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
phenanthrene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285
pyrene	bdl	bdl	bdl	bdl	bdl
dl	0.224	0.207	0.308	0.280	0.285

Results of organochlorine pesticide and total PCB analyses in mg/kg dry weight for field duplicate (DUP) soil/sediment samples collected from five sites at Caddo Lake National Wildlife Refuge in 2002 (Note - dl is the analytical detection limit; and bdl is below the analytical detection limit.

Analyte	Site 5 DUP	Site 10 DUP	Site 22 DUP	Site 31 DUP	Site 42 DUP
1,2,3,4-tetrachlorobenzene	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
1,2,4,5-tetrachlorobenzene★	0.000248	0.000578	0.00265	0.00169	0.000462
dl	0.000167	0.000155	0.000308	0.000281	0.000284
aldrin	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
HCB	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
heptachlor	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
total PCB★	0.00631	0.00312	0.0151	0.0108	0.00935
dl	0.00167	0.00155	0.00154	0.00140	0.00142
αBHC	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
αchlordane	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
βBHC	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
cis-nonachlor	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
δBHC	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
dieldrin	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
endosulfan II	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
endrin	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
γBHC	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
γchlordane	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
heptachlor epoxide	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
mirex	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
o,p'-DDD★	bdl	bdl	0.00173	0.000666	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
o,p'-DDE★	bdl	bdl	0.000344	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
o,p'-DDT★	bdl	bdl	0.00128	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
oxychlordane★	bdl	bdl	0.000335	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
p,p'-DDD★	bdl	bdl	0.00188	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
p,p'-DDE★	0.000219	0.000199	0.00617	0.00116	0.00296
dl	0.000167	0.000155	0.000308	0.000281	0.000284
p,p'-DDT★	bdl	bdl	0.00523	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
pentachloro-anisole	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284
toxaphene	bdl	bdl	bdl	bdl	bdl
dl	0.00167	0.00155	0.00154	0.00140	0.00142
trans-nonachlor	bdl	bdl	bdl	bdl	bdl
dl	0.000167	0.000155	0.000308	0.000281	0.000284

★Denotes detected above the analytical detection limit.

APPENDIX D
(FIELD OBSERVATIONS)

FIELD OBSERVATIONS

Any type of anomalies (i.e., drum, pipeline, solid waste, foundations, etc.) observed during the field sampling conducted in April and May, 2002, were noted. Coordinates for these sites were entered into a geographic information system database and are presented on the map on page D2. Photographs of these observations are presented on pages D3 through D6.

USFWS Field Observations at Caddo Lake NWR, 2002

ID	DATE	TIME	COMMENTS
O-1	4/23/2002	0914	old house site, near smapling site 1.
O-2	4/23/2002	1046	historic fence line running north-south.
O-3	4/23/2002	1057	2 flags and pvc marked point 22.
O-4	4/23/2002	1106	small litter pile, beer bottles and rubber hose.
O-5	4/23/2002	1159	possible caddo mound.
O-6	4/23/2002	1221	8' section of old iron pipe.
O-7	4/23/2002	1502	rail wheel and empty bucket.
O-8	4/23/2002	1635	gas pipeline ROW.
O-9	4/23/2002	1640	old railroad rails and chunk of concrete.
O-10	4/23/2002	1800	sheet metal.
O-11	4/23/2002	1802	barrel or old washtub.
O-12	4/23/2002	1818	9-1gal containers, 2 glass bottles.
O-13	4/24/2002	1235	1gal plastic container, DOT#2E0879, 80234, $2.29.
O-14	4/24/2002	1254	deer stand.
O-15	4/24/2002	1255	1" cable around tree.
O-16	4/24/2002	1300	1 gallon jug, chain bar oil.
O-17	4/24/2002	1325	1gallon jug.
O-18	4/25/2002	1307	old barrow pit.
O-19	4/25/2002	1402	center of testing grounds, numerous sheet metal, barrels, etc.
O-20	4/25/2002	1430	stressed vegetation.
O-21	5/20/2002	1506	open brick manhole.
O-22	5/21/2002	1155	big hole in the ground.
O-23	5/21/2002	1210	cleared area, void of vegetation.
O-24	5/21/2002	1315	broken piece of clay pipe.

Observation Point 1. Brick mound; possible remnants of house foundation.

Observation Point 3. PVC pipe; possible hunting marker.

Observation Point 5. Earthen mound; possible Caddoan burial site.

Observation Point 6. Discarded section of iron pipe approximately 8 feet (2.4 meters) in length.

Observation Point 8. Underground natural gas pipeline right-of-way.

Observation Point 9. Discarded railroad rails.

Observation Point 11. Remnants of discarded metal wash tub.

Observation Point 12. Discarded plastic jugs.

Observation Point 13. Discarded plastic jug with DOT No. 2E0879.

Observation Point 15. Abandoned logging anchoring cable attached to base of pine tree.

Observation Point 18. Barrow pit.

Observation Point 19. Photographs of debris in old signal test area, east of the magazine area.

Observation Point 20. Area of stressed vegetation in old signal test area.

Observation Point 21. Opened sewer manhole.

Observation Point 22. Barrow hole filled with water.

Observation Point 23. Cleared area with sparse vegetation leading to erosion.

Observation Point 24. Broken piece of clay pipe.